RULES
AND
REGULATIONS

1950

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LLOYD'S REGISTER OF SHIPPING

UNITED WITH THE BRITISH CORPORATION REGISTER

NOTICE IS HEREBY GIVEN THAT AT A MEETING OF THE GENERAL COMMITTEE, HELD ON THE 19TH APRIL, 1951, ADDITIONS AND AMENDMENTS WERE MADE TO THE UNDERMENTIONED SECTIONS IN THE SOCIETY'S RULES FOR THE CONSTRUCTION AND CLASSIFICATION OF STEEL SHIPS.

RULES FOR STEEL SHIPS

Page 50, **Section 19, Clause 5,** in 1950 Edition (*Page 44, paragraph* D 1911, *in 1951 Edition*). This clause has been deleted and replaced by the following:—

> 5. **Centre Line Bulkheads.**—Where a complete centre line division is fitted in deep tanks the arrangements are to be as required by **Section 20, Clause 7.**

In the 1951 Edition read "D 2015" *and* "D 2016" *for* "**Section 20, Clause 7.**"

Page 52, **Section 21, Clause 1** (*a*), in 1950 Edition (*Page 47, paragraph* D 2101, *in 1951 Edition*). This clause has been deleted and replaced by the following:—

> 1. **Oil Fuel.**—(*a*) Oil fuel having a flash point above 150° F. may be carried as cargo in deep tanks or peak tanks providing the scantlings and arrangements of the tanks are in accordance with the requirements of **Section 20** for oil fuel bunkers, except that the riveting may be as required for deep tanks by Table 52 (G) and the centre line bulkhead need not be fitted; if, however, the tanks are intended to be partially filled only, the requirements of **Section 20** are to be complied with in all respects.

In the 1951 Edition read "D 20" *for* "Section 20" *and* "Table 52 H" *for* "Table 52 (G)."

Page 107 in 1950 Edition (*Page 103 in 1951 Edition*). Table 18, Note 4. This note has been amended to read as follows :—

> 4. **'Tween Deck Height.**—If the midship height of the 'tween decks below the strength deck exceeds 8 feet 6 inches at side, the area of the strength deck corrected as required by note 2 (*b*) is to be increased by 5 per cent of the Rule area of the second deck in two deck ships, and 7 per cent of the Rule area of the second deck in three deck ships, per foot increase in 'tween deck height. If the second 'tween deck height exceeds 8 feet 6 inches, a further increase may be required.

RULES FOR PETROLEUM TANKERS

Page 198, **Section 40, Clause 10**, in 1950 Edition (*Page 62, paragraph* D 4010, *in 1951 Edition*). The first sentence of this clause has been amended to read as follows :—

> The Draught d for use in the Tables is to be the summer moulded draught corresponding to the freeboard desired, but should not be less than $\cdot 85D - \cdot 0025D^2$.

Page 200, **Section 46, Clause 1** (*c*), in 1950 Edition (*Page 65, paragraph* D 4603, *in 1951 Edition*), This clause has been amended to read as follows :—

> For the support of transverse bulkheads at the ends of tanks exceeding 40 feet in length, *see* Table 64, note 2.

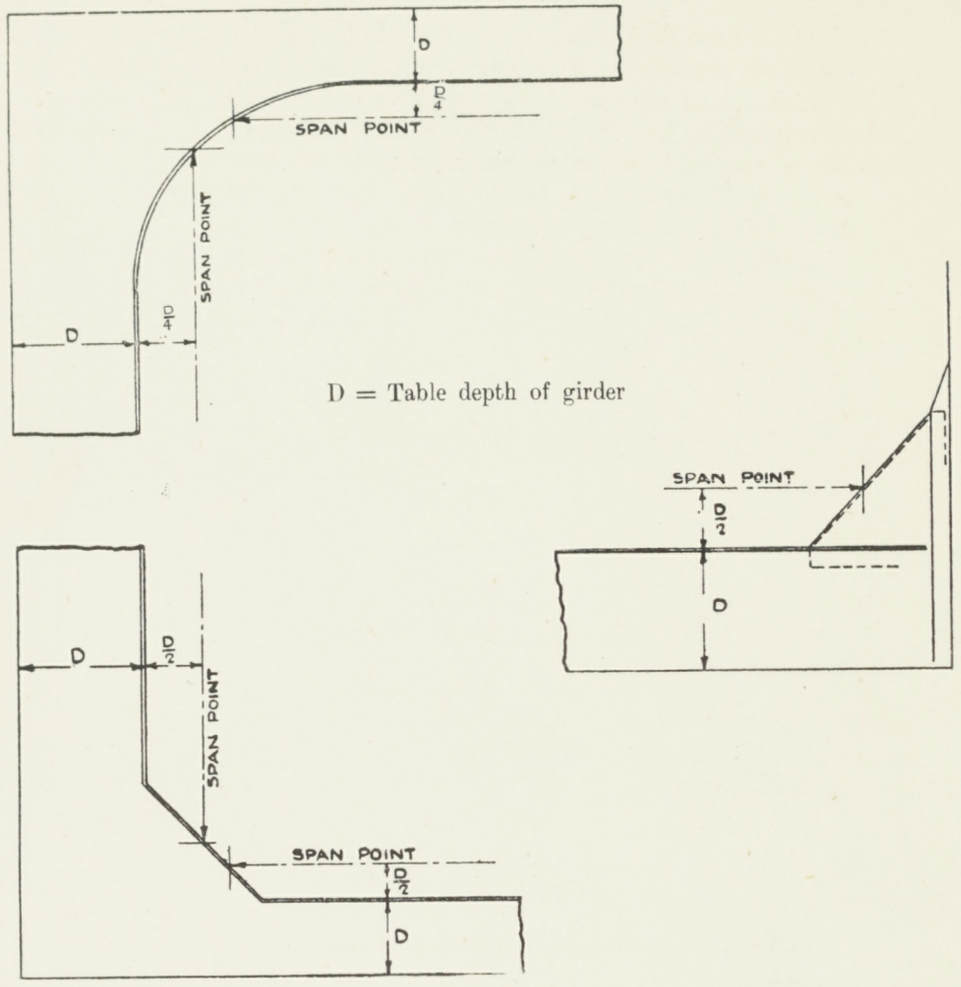
Pages 214–215 in 1950 Edition (*Pages 196–197 in 1951 Edition*). Table 64. The following sentence has been added at the end of Note 1 (*a*) "h =" :—

> Where vertical webs to transverse bulkheads other than webs at the centre line are attached to continuous girders at the bottom and deck thus forming a ring system of structure, Numeral = $\cdot 8b \times h$.

The figure "35 feet" in not 2 has been amended to read "40 feet."

Page 216 in 1950 Edition (*Page 198 in 1951 Edition*). Table 65. The figure "35 feet" in the sub-heading and in note 4 has been amended to read "40 feet" in both places.

Page 239 in 1950 Edition (*Page 221 in 1951 Edition*). Span Point. The sketches under the heading "**Span Point for Primary Supporting Members**" have been modified as shown.



RULES FOR PUMPING AND PIPING

Page 248, paragraph 16, in 1950 Edition (*Page 224, paragraph* E 215, *in 1951 Edition*). The following sentence has been added :—

> Where non-refrigerated hatch trunks are intended for the carriage of general cargo while the adjacent spaces in the same hold are intended for the carriage of refrigerated cargoes, details of the draining arrangements for the hatch trunks are to be submitted for special consideration.

By order of the Committee,

71, Fenchurch Street, London, E.C.3.
19th April, 1951.

P. E. CLEMENT,
Secretary.

LLOYD'S REGISTER OF SHIPPING

UNITED WITH THE BRITISH CORPORATION REGISTER

RULES AND REGULATIONS

ERRATUM.

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RULES AND REGULATIONS

FOR THE

CONSTRUCTION AND CLASSIFICATION OF STEEL SHIPS

71, FENCHURCH STREET, LONDON, E.C.3

1950

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TABLE OF CONTENTS OF THE RULES.

	Page.
Administration of the Society, terms of Subscription to the Register Book, Duties of the Surveyors, &c.	1
Aluminium Alloys for Shipbuilding purposes, tentative requirements for quality and testing of	481
Anchors and Chains, Proving Establishments for	487
Annual or Occasional Surveys	15
Construction of Steel Ships	33
Classification of Steel Ships and their Machinery, General Regulations for the	9
Electrical Equipment...	371
„ „ Appendices for	437
Electrical Propelling Machinery	357
„ „ „ Appendices for	437
Engines and Boilers of Steam Ships	285
Fire Extinguishing Arrangements	279
Freeboard Markings for Steamers and Sailing Ships	509
Heavy Oil Engines and their Auxiliaries	339
Ice Navigation, Strengthening for	41
Oil carried as Cargo in Deep Tanks and Peak Tanks	52
Oil used as Fuel Carried in Deep and Double Bottom Tanks	50
Periodical Survey Requirements—Hull	16
„ „ „ Machinery	20
Petrol and Paraffin Engines	333
Petroleum Tankers, Construction of	197
Pumping and Piping, Rules for	247
Materials, Quality and Testing of	465
Reduction Gearing intended for Main Propelling Machinery	307
„ „ „ „ Auxiliary Electrical Generating Machinery ...	311
Refrigerating Machinery and Appliances of Ships	453
Scantlings and Equipment of Steel Ships, Tables for	77
„ for Petroleum Tankers, Tables for	208
Ships not originally built under the Society's Survey, Classification of	25
Steel Manufacturers	507
Welded Pressure Vessels	317
Welding, Electric Arc, in Ship Construction	67

NOTE.—A relevant Index precedes each Main Section of the Rules.

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1st July, 1949.

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1st July, 1949.

INDEX.

CONTINENTS.

EUROPE ... xxiv-xxxiv
AMERICA ... xxxv
AFRICA ... xxxviii
ASIA ... xxxix
AUSTRALIA ... xl

	Page
Aberdeen	xxvi
Adelaide	xl
Aden	xxxviii
Alexandria	xxxviii
ALGERIA	xxxviii
Algiers	xxxviii
Amsterdam	xxxii
Antwerp	xxxi
Aruba	xxxvi
Auckland	xl
Augsburg	xxxii
AUSTRIA	xxxi
Balboa	xxxvi
Baltimore	xxxv
Bangkok	xxxix
Barcelona	xxxiii
Bari	xxxiii
Barrow	xxvi
Barry	xxvi
Batavia	xxxix
Belfast	xxvi
BELGIUM	xxxi
Bergen	xxxiii
Bilbao	xxxiii
Birmingham	xxvi
Bombay	xxxix
Bordeaux	xxxi
Borlange	xxxiv
Boston, Lincs.	xxvii
Boston, Mass.	xxxv
Boulogne	xxxi
Bremerhaven	xxxii
Brisbane	xl
Bristol	xxvi
BRITISH WEST INDIES	xxxviii
Budapest	xxxii
Buenos Aires	xxxviii
BURMA	xxxix
Cadiz	xxxiii
Calcutta	xxxix
CANADA	xxxvii
Cape Town	xxxviii
Cardiff	xxvi
CEYLON	xxxix
Chicago	xxxv
CHILE	xxxviii
CHINA	xxxix
Christchurch	xl
Cleveland	xxxv
Colombo	xxxix
Copenhagen	xxxi
CUBA	xxxviii
Curacao	xxxvi
CZECHOSLOVAKIA	xxxi
Dartmouth	xxvi
Demerara	xxxviii
DENMARK	xxxi
Dortmund	xxxii
Dover	xxvi
Dublin	xxviii
Dundee	xxviii
Dunedin	xl
Dusseldorf	xxxii
EAST AFRICA	xxxviii
EAST INDIAN ARCHIPELAGO	xxxix
EGYPT AND RED SEA	xxxviii
EIRE	xxvi
Falmouth	xxvi
FAROE ISLANDS	xxxi
FINLAND	xxxi
Fleetwood	xxviii
FRANCE	xxxi
Fremantle	xl
Galveston	xxxv
Gdynia	xxxiii
Genoa	xxxii
Georgetown	xxxviii
GERMANY	xxxii
GIBRALTAR	xxxii
Glasgow	xxvii
Gothenburg	xxxiv
GREAT BRITAIN	xxiv
GREECE	xxxii
Greenock	xxvii
Grimsby	xxvii
Groningen	xxxii
Halifax	xxxvii
Hamburg	xxxii
Hartlepool	xxvii
Havana	xxxviii
Havre	xxxi
Helsingborg	xxxiv
Helsingfors	xxxi
Hilbringen	xxxii
HOLLAND	xxxii
HONG KONG	xxxix
Hull	xxviii
HUNGARY	xxxii
ICELAND	xxxii
INDIA	xxxix
Ipswich	xxviii
IRELAND	xxiv
ITALY	xxxii
Jacksonville	xxxv
JAPAN	xxxix
Karachi	xxxix
Katowice	xxxiii
Kiel	xxxii
Kingston, Jamaica	xxxviii
Kobe	xxxix
Kongsberg	xxxiii
Lagos	xxxviii
Leeds	xxviii
Leghorn	xxxiii
Leith	xxviii
Lisbon	xxxiii
Liverpool	xxviii
London	xxviii
London District	xxviii
Los Angeles	xxxv
Lyttelton	xl
Macassar	xxxix
Madras	xxxix
Malmo	xxxiv
MALTA	xxxiii
Manchester	xxx
Manila	xxxix
Marseilles	xxxi
Melbourne	xl
Middlesbrough	xxix
Milford Haven	xxix
Mobile	xxxv
Mombasa	xxxviii
Montevideo	xxxviii
Montreal	xxxvii
Nantes	xxxi
Naples	xxxiii
NETHERLANDS ANTILLES	xxxvii
New Orleans	xxxv
New York	xxxv
NEW ZEALAND	xl
Newcastle-on-Tyne	xxix
Newcastle, N.S.W.	xl
Newfoundland	xxxvi
Newport, Mon.	xxix
Newport News	xxxv
NIGERIA	xxxviii
NORTH AFRICA	xxxviii
NORWAY	xxxiii
Nottingham	xxix
Oslo	xxxiii
PAKISTAN	xxxix
Palermo	xxxiii
Panama, C.Z.	xxxvi
Paris	xxxi
Penang	xxxix
Philadelphia	xxxv
Pilsen	xxxi
Piræus	xxxii
Pittsburgh	xxxvi
Plymouth	xxix
POLAND	xxxiii
Port Arthur, Ont	xxxvii
Port Elizabeth	xxxviii
Port Natal	xxxviii
Port of Spain	xxxviii
Port Said	xxxviii
Portland, Or.	xxxvi
PORTUGAL	xxxiii
Quebec	xxxvii
Queensland	xl
Quincy, Mass.	xxxvi
Rangoon	xxxix
Reykjavik	xxxii
Rio de Janeiro	xxxviii
Rosario	xxxviii
Rotterdam	xxxii
Rouen	xxxii
St. Etienne	xxxii
Saint John, N.B.	xxxvii
Saint John's, N.F.L.	xxxvii
San Francisco	xxxvi
Santos	xxxviii
Scunthorpe	xxviii
Seattle	xxxvi
Shanghai	xxxix
Sheffield	xxx
SIAM	xxxix
Sindri Bihar	xxxix
Singapore	xxxix
Sourabaya	xxxix
SOUTH AFRICA	xxxviii
SOUTH AMERICA	xxxviii
Southampton	xxx
SPAIN	xxxiii
Spezia	xxxii
Split	xxxiv
Stockholm	xxxiv
STRAITS SETTLEMENTS	xxxix
Suez	xxxviii
Sunderland	xxx
Swansea	xxx
SWEDEN	xxxiv
Sydney, N.S.	xxxvii
Sydney, N.S.W.	xl
SWITZERLAND	xxxiv
Talcahuano	xxxviii
Taranto	xxxiii
Thorshavn	xxxi
Tientsin	xxxix
Toronto	xxxvii
Trieste	xxxiii
TRINIDAD	xxxviii
TUNISIA	xxxviii
UNITED STATES	xxxv
Valparaiso	xxxviii
Vancouver	xxxvii
Victoria, Canada	xxxvii
VIENNA	xxxi
Vizagapatam	xxxix
Wellington	xl
Whyalla	xl
Winterthur	xxxiv
Yokohama	xxxix
YUGOSLAVIA	xxxiv

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DARTMOUTH (*see* PLYMOUTH).

DOVER.

Address: British Railways (Southern Region), Marine Factory, Snargate Street, Dover.
Telephone No. 800, Ext. 67.
Telegrams: Stewart, c/o Foremost.

Ship and Engineer Surveyor ...	*R. Stewart

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DUBLIN, EIRE.

Office: 30a, Lower O'Connell Street.
Telephone No. 73441.

Ship and Engineer Surveyor ... W. H. Waggott

DUNDEE, *with Arbroath, Montrose and Perth.*

Office: 19 & 20, Prudential Buildings, Albert Square, Dundee.
Telephone No. 2394.
Telegrams: Lloyds Register.

Ship Surveyor ... ... S. Bowman

FALMOUTH, *with all ports on the coast between Looe and Padstow, including Fowey, Par, Helston, Porthleven, Penzance, St. Ives, Hayle, Portreath and Newquay; also the Scilly Islands.*

Office: 3, Market Street, Falmouth.
Telephone No. 32.
Telegrams: Lloyds Register.

Ship and Engineer Surveyors ... A. D. Morrison
D. A. MacFarlane

Ship Surveyor ... ... A. M. Jenkins

FLEETWOOD (*see* LIVERPOOL).

GLASGOW, *with the North Bank of the Clyde from Dumbarton; Renfrew, Paisley, Ports on the Coast from Largs to Stranraer, also Annan, Oban, Alloa, Grangemouth and Bo'ness.*

Office: 95, Bothwell Street, Glasgow, C.2.
Telephone No. 6491 Central—4 lines.
Telegrams: Register.

Principal Surveyor for Scotland G. Webster, O.B.E., D.Sc.

Ship Surveyors

R. Dunsmuir
H. J. Thomson
J. R. Clark, B.Sc.
A. Dalrymple Aitken
J. S. Thomson
W. Malcolm, B.Sc.
A. R. Baxter
W. Macmillan
J. H. Tait
S. W. Bolwell, M.Eng.
D. B. Cook
C. J. G. Jensen, B.Sc.
G. Cockburn
H. Berry
G. Fullerton
J. F. Edgar
J. T. Deuchars
J. Ballantine
J. Fleming
J. McCallum, B.Sc.
J. R. Sarginson, B.Eng.
J. C. Brown
R. G. Lockhart
J. C. Struthers
A. J. P. Crawford
F. V. Bell

Principal Engineer Surveyor ... A. R. Riddell

Principal Surveyor for Metals ... W. E. Lewis, B.Sc.

Ship and Engineer Surveyors

T. D. Shilston
R. J. Easthope
A. J. Brown
G. H. Macdonald, B.Sc.
R. Shaw
E. Earnshaw
H. Waugh
N. C. Juniper

Engineer Surveyors

F. R. Dale, B.Sc.
H. K. Taylor
J. McLaren
F. B. Gray
T. Donaldson
J. Crawford
P. Weston
A. G. Smith
R. J. Yorston
J. W. Wilson

Electrical Engineer Surveyors H. G. Findlay
S. C. Johnson
J. M. Gardiner
C. Haffner

Surveyors of Forgings and Castings ... ... H. A. G. Inness
R. Steel
D. Brown

Surveyors for Steel-testing duties J. E. Steele
A. Ligertwood
T. Macgregor
T. H. Dodsworth
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A. O. Davies
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GREENOCK AND PORT GLASGOW, *with Campbeltown and Rothesay.*

Office: Commercial Bank Buildings, 14, Cross-shore Street, Greenock.
Telephone No. 295.
Telegrams: Lloyds Register.

Principal Surveyor ... ... A. G. Akester, M.Sc.

Ship Surveyors ... ... K. Inglis, B.Sc.
A. E. Heap, B.Eng.
J. L. Roberts
H. J. H. Gould
J. A. Jameson

Engineer Surveyors ... ... C. N. Hunter
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Office: Bank Chambers, 2, Freeman Street, Grimsby.
Telephone No. 3156.
Telegrams: Lloyds Register.

Principal Surveyor for the Hull and Grimsby Districts ... J. McMillan
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Ship and Engineer Surveyor ... G. C. Vaux

Ship Surveyor ... ... J. MacLeod

Engineer Surveyor ... ... E. G. Hickling

HARTLEPOOL AND WEST HARTLEPOOL.

Office: 47, Church Street, West Hartlepool.
Telephone No. West Hartlepool 2432.
Telegrams: Lloyds Register.

Principal Surveyor for the Middlesbrough and Hartlepool Districts H. Dickerson
(Resident at Middlesbrough).

Principal Engineer Surveyor for the North East Coast Area ... H. P. Southwell
(Resident at Newcastle-on-Tyne).

Ship Surveyors ... ... W. J. Craig, B.Sc.
W. D. Johnston

Ship and Engineer Surveyor ... J. T. Findlay

Engineer Surveyors ... ... S. Wood
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Telephone Nos. 36873—2 lines.
Telegrams: Lloyds Register.

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	N. Chambers
	C. S. Newton
	J. Dobbie, D.S.C.
Engineer Surveyors	K. G. Kirby
	J. A. Clay
Ship Surveyors	J. R. Macleod, M.C.
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Surveyor for Steel-testing duties J. S. Ellis

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Telephone No. 23666.

Ship and Engineer Surveyor ...	E. R. Hall, B.Sc.
Engineer Surveyors	L. A. Whyatt
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Telephone No. 35506.
Telegrams: Lloyds Register.

Ship and Engineer Surveyor ...	A. W. Oxford
Engineer Surveyors	A. Campbell
	G. G. Hay
Ship Surveyors	R. N. Hunter
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Telephone Nos. Central 8891—5 lines.
Telegrams: Register.

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Liaison Officer	A. M. Kennedy
Ship Surveyors	A. W. Jackson, M.Inst.C.E.
	H. S. Newton, B.Sc.
	H. C. Murray
	W. E. Marlborough
	T. B. Tillery
	D. Lockhart
	T. J. Roberts
	A. Lee
	T. F. Naisby
	T. S. Turpie
Senior Engineer Surveyor ...	G. Pickering
Ship and Engineer Surveyors ...	C. W. Reed, B.Sc.
	J. H. Milton
	J. V. Naylor
	J. C. Murray
	A. Ellison
Engineer Surveyors	F. C. Lloyd
	F. Southern
	E. F. Butler
	J. Moar
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Telegrams: Committee, Fen, London.
Cablegrams: Committee, London.
Telephone: Royal 3551.

Principal Surveyor	H. L. Sutherst
Ship and Engineer Surveyors ...	R. W. Coomber
	J. L. Smith
	W. T. Mathieson
	F. E. Turpie
	J. B. Smail
	B. S. Bielawski
	E. M. Sellex
Ship Surveyors	T. R. McIlvenna
	C. Lloyd Roberts
	W. A. Cormack
	J. H. Greenhalgh
	A. J. W. Hedger
	T. Nell
	E. Little
	T. M. G. Jobling
	A. J. Smith
Engineer Surveyors	E. Wilson
	R. J. Dunn
	R. Henderson
	A. C. Widgery
	A. E. Evans
	D. A. R. Crowley
	J. H. Gilbert, M.V.O.
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Telephone No. Ipswich 2518.

Ship and Engineer Surveyor ...	H. Y. Bell

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Telegrams: Lloydreg, Manchester.

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Engineer Surveyors	B. Hill N. W. Thomas W. A. Cook W. J. Isaac T. H. Smeaton G. M. Kersey
Ship Surveyor	J. M. Miller
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Telephone No. 43431/2.
Telegrams: Lloyds Register.

Principal Surveyor for the Middlesbrough and Hartlepool Districts	H. Dickerson
Principal Engineer Surveyor for the North East Coast Area ... (*Resident at Newcastle-on-Tyne*).	H. P. Southwell
Ship Surveyors	A. P. Scott J. D. Rufus J. G. Lumley, M.B.E. E. Flynn
Ship and Engineer Surveyor ...	C. N. Stuart
Engineer Surveyors	F. C. Smith E. Howey J. H. Harbottle
Surveyor for Metals	T. W. Bushell
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Telephone No. 21391—3 lines.
Telegrams: Register.

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Principal Engineer Surveyor for the North East Coast Area ...	H. P. Southwell
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Ship and Engineer Surveyors ...	A. Watt J. H. Matthews T. A. Orde T. O. Morris T. D. Potts
Engineer Surveyors	R. W. Skinner A. Butler C. W.White J. W. Walker R. R. Bolton A. Huntingford D. A. Taylor W. H. Scurr S. N. Clayton
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Telephone No. 41176.
Telegrams: Lloyds Register.

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Engineer Surveyor	J. B. Taylor
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Telephone No. 5867.
Telegrams: Lloydreg, Plymouth.

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Telegrams: Lloyds Register.

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Engineer Surveyors	G. P. Smedley, B.Eng. I. L. Wren J. P. Smith
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Telephone No. 2353.
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Engineer Surveyor	C. N. Lamb
Ship Surveyors	J. M. Robertson *(Special Surveyor for Yachts)* E. M. Hart N. W. Vine G. Smart

SUNDERLAND.

Office: 55, Fawcett Street, Sunderland.
Telephone No. 4093—2 lines.
Telegrams: Lloyds Register.

Principal Surveyor	A. Pickworth, O.B.E., D.Sc.
Principal Engineer Surveyor for the North East Coast Area ... *(Resident at Newcastle-on-Tyne).*	H. P. Southwell
Ship Surveyors	P. D. Croudace J. L. Rennie A. T. S. Sheffer N. F. H. Duncan R. M. Wilson J. K. Young D. J. Maclachlan
Ship and Engineer Surveyors ...	W. H. Fraser J. Lundgren
Engineer Surveyor	C. E. Booker
Surveyors of Forgings and Castings	C. S. Porter A. E. B. Galliford K. W. Fox
Electrical Engineer Surveyors...	R. M. Hills S. D. Brand

SWANSEA, *with Llanelly, Neath and Port Talbot.*

Office: Powell Duffryn House, Adelaide Street, Swansea.
Telephone No. Swansea 3860.
Telegrams: Lloyds Register.

Ship and Engineer Surveyor ...	G. Dixon
Engineer Surveyor	W. R. T. Blackwood
Ship Surveyor	G. Ord
Surveyors for Steel-testing duties	L. S. Horton P. Harris

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VIENNA.

Office: Wilbrandtgasse 41/4, Vienna 110.
Telegrams: Surveyor, Vienna.

Acting Surveyor for Steel-testing duties ... ... H. Kolbow

BELGIUM.

ANTWERP.

Office: Mersey House, 1, Quai de Rouen, Antwerp.
Telephone: 209.40.
Telegrams: Register.

Principal Surveyor for Belgium R. Lascelles

Ship Surveyors ... ... J. A. Mavor, O.B.E.
H. C. Young
A. van Haesendonck

Ship and Engineer Surveyors ... H. C. Murray
G. A. Valckeneers
J. E. Martin
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Engineer Surveyors ... ... J. Manson
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Surveyor of Forgings and Castings ... ... W. H. Hatt

Surveyors for Steel-testing duties F. Hulley
P. H. Sahlender

CZECHOSLOVAKIA.

PILSEN.

Office: Havlickova 19, Pilsen.
Telephone:
Telegrams:

Engineer Surveyor ... ... Ing. L. Melichar

DENMARK.

COPENHAGEN.

Office: Holbergsgade 11, Copenhagen K.
Telephone: Central 5760.
Telegrams: Engineer.

Ship and Engineer Surveyors ... L. F. Klausen
K. L. Jensen
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Ship Surveyors ... ... G. Buchanan, B.Sc.
S. Sandersen
W. D. Lydersen, B.Sc.
H. K. Juul

Surveyor for Steel-testing duties C. H. Kruhoffer

FAROE ISLANDS.

Office: 35, Jonas Broncks göta Post Box 43, Thorshavn, Faroe Islands.
Telegrams: Autoværksted, Thorshavn.

Ship and Engineer Surveyor ... *Vilhelm Nielsen

FINLAND.

HELSINGFORS.

Office: Sjofartstyrelsen.
Telephone: 33 207.
Telegrams: Surveyor, Helsingfors.

Ship and Engineer Surveyor ... *Ossian Tybeck

FRANCE.

PARIS.

Office: 80, Boulevard Haussmann, Paris, 8.
Telephone No. Europe 37-88.
Telegrams: Lloydreg.

(*Communications should be addressed to* Jean Taxil.)

Surveyor for Steel-testing duties H. J. Martin
c/o Ste. d'Escaut et Meuse, Anzin (Nord).

BORDEAUX.

Office: 38, Rue du Jardin Public, Bordeaux.
Telephone No. 49-13.
Telegrams: Register.

Ship and Engineer Surveyor ... *P. Fleuret

BOULOGNE.

Office 26, Rue Belvalette, Boulogne.
Telephone No. 6.57.

Ship and Engineer Surveyor ... *R. A. Masset

HAVRE.

Office: Baraquement No. 202, Quai George V., Havre.
Telephone No. 42-15.
Telegrams: Lloydsreg, Havre.

Ship and Engineer Surveyor ... L. S. Sims

MARSEILLES.

Office: 8, Rue de la République, Marseilles.
Telephone: Colbert 3093.
Telegrams: Lloydsreg.

Ship and Engineer Surveyor ... P. Fondeur

NANTES, *including St. Nazaire, Brest and La Rochelle.*

Office: 8 bis, Rue de Bréa, Nantes.
Telephone: No. 310.49.
Telegrams: Lloydsreg, Nantes.

Ship and Engineer Surveyor ... B. O. Gibbs

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Telephone: R1. 19.39.
Telegrams: Lloydreg.

Ship and Engineer Surveyor ... J. Grandison

ST. ETIENNE.

Office: 25, Rue Gambetta, St. Etienne (Loire).
Telephone No. 21-98.

Surveyor for Steel-testing duties *E. F. Banchet

GERMANY.

AUGSBURG.

Office: Malmedystrasse 8, Augsburg.
Telephone No. 6300.
Telegrams: Schneider, Malmedystrasse, Augsburg.

Engineer Surveyor ... ... H. K. Schneider

BREMERHAVEN.

Office: Administrative Building, Room 202, Navy Compound.
Telephone: 5055.
Telegrams: Surveyors.

Ship and Engineer Surveyor ... J. P. Gateley

DORTMUND.

Office: Karl Marx Strasse 8, Dortmund.

Engineer Surveyor ... ... J. Quast

DUSSELDORF.

Office: Oxford House, Rooms 212-214, Breite Strasse 67, Dusseldorf.
Telephone No.
Telegrams:

Ship and Engineer Surveyor ... D. R. Walburn
Engineer Surveyors ... ... M. Berg
F. Schnell
J. Loogen

HAMBURG.

Office: 3rd Floor, 25 Ballindamm, Hamburg 1.
Telephone No. 33. 35. 39.
Telegrams: Surveyors, Hamburg.

Ship and Engineer Surveyor ... W. A. Allan
Ship Surveyor ... ... F. H. Ohlzen

HILBRINGEN-SAAR.

Surveyor for Steel-testing duties in the Saar District ... ... *G. Mathieu, Ing.

KIEL.

Office: 23, Düppelstrasse, Room 23, Kiel.
Telephone No. 31240.
Telegrams: Lloyd's Register, Kiel.

Ship and Engineer Surveyor ... J. Bowman
Ship Surveyor ... ... A. Holtz

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GIBRALTAR, *with a district including Tangier, Ceuta, Tetuan (Ro Martin), Melilla and Villa Sanjurjo.*

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Telephone Nos. 884 and 277 Automatic.
Telegrams: Engcrom Gibraltar.

Ship and Engineer Surveyor ... *W. T. Cromby

GREECE.

PIRÆUS.

Office: 50A, Odos Notara, Piræus.
Telephone No. 40-664.
Telegrams: Register.

Ship and Engineer Surveyor ... A. C. Bone

HOLLAND.

Principal Surveyor for Holland... P. H. van der Weel (at Rotterdam).

ROTTERDAM.

Office: Westerkade 5b, Post Office Box. No. 701, Rotterdam.
Telephone: 25355.
Telegrams: Lloyds Register.

Principal Surveyor for Holland... P. H. van der Weel

Ship Surveyors ... ... M. P. Jonker
C. Lodder
W. B. Scheelings
Ir. P. J. N. Jiskoot
G. J. de Jong
A. J. Kraayenbrink

Ship and Engineer Surveyors ... C. H. Bource
P. F. Willemse
J. F. Vrouwes
A. C. Buijze
A. van Hasselt

Engineer Surveyor ... ... E. M. Dudock

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AMSTERDAM.

Office: Prins Hendrikkade 86, Amsterdam.
Telephone No. 43895.
Telegrams: Lloyds Register.

Ship and Engineer Surveyors ... K. Kuijt
G. Verkroos

Ship Surveyors ... ... L. H. Wehrmeijer
I. G. ten Sijthoff

Engineer Surveyor ... ... A. C. van Bezuye

GRONINGEN.

Office: Rijksstraatweg 234, Haren-Groningen.
Telephone No. 44926.
Telegrams: Lloyds Register.

Ship Surveyors ... ... A. Zur-Muhlen
M. J. de Bilt

HUNGARY.

BUDAPEST.

Office: Bakacs U.3. 1115, Budapest.

Surveyor for Steel-testing duties *Anton Schneider

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REYKJAVIK.

Office: Grenimal 6, Reykjavik.
Telephone: Simi 7586.
Telegrams:

Ship and Engineer Surveyor ... *V. R. Jessen

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Principal Surveyor for Italy ... A. T. Griffith (at Genoa)

GENOA AND SPEZIA.

Office: 2/3, Piazza Cavour, Genoa.
Telephone: 22-862.
Telegrams: Surveyors, Genoa.

Principal Surveyor for Italy ... A. T. Griffith

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Dott. Ing. D. Garré

Engineer Surveyor ... ... H. F. Mansfield

Surveyor for Steel-testing duties G. Maggi

LEGHORN.

Office: 9, Scali d'Azeglio, Leghorn.
Telephone No. 33155.
Telegrams: Benvenuto, Leghorn.

Ship and Engineer Surveyor ... *P. L. Benvenuto

NAPLES, *including Taranto, Bari and Palermo.*

Office: Via A. Depretis 31, Naples.
Telegrams: Surveyors.

Ship and Engineer Surveyors ... F. N. Sutcliffe
A. Ansaldo

TRIESTE.

Office: Via Mazzini No. 9, Trieste.
Telephone No. 44-20.
Telegrams: Register.

Ship and Engineer Surveyors ... J. McAfee
M. Bonivento
S. Cesari

Ship Surveyors ... ... S. B. Lumsden
Dott. Ing. D. Versa
A. M. Hopkins

MALTA.

MALTA.

Office: 1/18, Qui Si Sana Mansions, Sliema, Malta.
Telephone No. Sliema 785.
Telegrams: Register, Malta.

Ship and Engineer Surveyor ... *J. J. Simmons, O.B.E.

NORWAY.

BERGEN.

Office: Nordenfjeldskes Bygning, 1, Slotsgate, Bergen.
Telephone No. 15634 (Private No. 98547 K).
Telegrams: Surveyor.

Ship and Engineer Surveyor ... S. A. Eide, B.Sc.

KONGSBERG.

Inspector of Forgings ... ... *K. J. Hansen

OSLO, *with a district extending from Halden to Lindesnaes.*

Office: Tollbodgatan 27, Oslo.
Telephone No. 424932.
Telegrams: Surveyor.

Ship and Engineer Surveyors ... P. Eide, B.Sc.
J. C. Bentley, M.B.E.

Engineer Surveyors ... ... L. Tveit
B. S. Witowski

POLAND.

GDYNIA.

Office: UL. Swietojanska 23, Gdynia.
Telephone: 26-36.
Telegrams: Lloydsreg.

Ship and Engineer Surveyors ... L. D. Trenchard
J. A. Boater

KATOWICE.

Office: Ulica Kilinskiego 20/1.
Telephone: 312-49.
Telegrams: Lloydreg, Katowice.

Surveyor for Steel-testing duties C. E. Dielman

PORTUGAL.

LISBON.

Office: P. Duque da Terceira 24-2°-E, Lisbon.
Telephone No. 24218.
Telegrams: Register.

Ship and Engineer Surveyor ... J. Guthrie

Engineer Surveyor ... ... W. A. Leggat

Ship Surveyor ... ... W. Ronald

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Principal Surveyor for Spain ... A. E. Scott
(at Bilbao)

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Office: Paseo de Colon 11, Barcelona.
Telephone No. 19601.
Telegrams: Surveyors.

Ship and Engineer Surveyor ... F. Larrucea

BILBAO, *with a district including Pasajes to Vigo.*

Office: Calle de Ibañez de Bilbao No. 22, Bilbao; Apartado de Correos No. 286, Bilbao.
Telephone No. 16139.
Telegrams: Register.

Principal Surveyor for Spain ... A. E. Scott

Ship Surveyor ... ... J. M. Barnett

Ship and Engineer Surveyors ... A. Coe
J. B. Goodier
A. de Bareno, B.Sc.

Engineer Surveyors ... ... J. M. Ruiz
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Telephone No. 2319.
Telegrams: Registro.

Ship and Engineer Surveyor ... G. T. B. Scullard

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Principal Surveyor for Sweden... S. Townshend (at Gothenburg)

GOTHENBURG, *with a district extending from Strömstad to Falkenberg, also the port of Kalmar, inclusive.*

Office: Norra Hamngatan 6, Gothenburg, C.
Telephone No. 17 02 80.
Telegrams: Surveyor.

Principal Surveyor for Sweden... S. Townshend

Ship Surveyors ... ... D. S. Forsyth
B. Grauers, Civ.Ing.
H. W. Larsén, Civ.Ing.
J. Burton-Davies, B.Sc.
B. Roslund

Ship and Engineer Surveyors ... K. G. Anander, Civ.Ing.
S. Johnsson

Engineer Surveyors ... ... A. Sjögren
C. O. Scotting
S. H. Berntsson
S. B. Bovin
S. Göransson

HELSINGBORG, *with a district extending from Halmstad to Landskrona, inclusive.*

Office: Kungsgatan 8, Helsingborg.
Telephone No. 10594.
Telegrams: Surveyor.

Ship and Engineer Surveyor ... T. Österberg

MALMO, *with a district extending from Malmö to Karlskrona, inclusive.*

Office: Skeppsbron 3, Malmö.
Telephone No. 21871.
Telegrams: Register.

Ship and Engineer Surveyors ... A. O. Börring
A. Ozols

Ship Surveyor ... ... N. S. Flensburg, Civ.Ing.

STOCKHOLM, *with all ports on the East Coast of Sweden north of Kalmar, and including the Islands of Gotland and Åland.*

Office: Slussplan 51, Stockholm, C.
Telephone No. 10 41 61.
Telegrams: Lloydsregister.

Ship and Engineer Surveyors ... H. B. Siggers
V. T. Bülow
F. S. J. Aspelin
I. Lager

Engineer Surveyor ... ... P. Gordh

Ship Surveyor ... ... H. O. Albertson, Civ.Ing.

Sub-Office at **BORLÄNGE.**

Surveyor for Metals ... ... S. Walterson

SWITZERLAND.

WINTERTHUR.

Office: Rudolfstrasse 1, Winterthur.
Telephone No. 81122, Internal 2256. (Home-28482.)
Telegrams:

Ship and Engineer Surveyor ... J. N. Buchanan, B.Sc.

YUGOSLAVIA.

SPLIT.

Office: Slavensko Setaliste 1, Split.
Telephone No. 3076.
Telegrams: Register.

Acting Surveyor ... ... *G. Majcen, B.Sc.

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AMERICA—UNITED STATES.

NEW YORK.

OFFICE: 17, BATTERY PLACE, NEW YORK, 4. (TELEGRAMS, *Nymdible;* TELEPHONE NOS. *Whitehall* 4-0220, 0221, 0222 & 0223.)
PRINCIPAL SURVEYOR FOR THE UNITED STATES (*including Panama and the Netherlands Antilles*) ... WM. BENNETT, O.B.E., B.Sc.

SHIP SURVEYORS.

W. J. Roberts, B.Eng. J. Todd
W. M. Palmer
(temporarily stationed at Quincy, Mass.)

SHIP AND ENGINEER SURVEYORS.

C. Macpherson, B.Sc. J. W. Belton Alfred W. Coates
F. A. J. Findley James A. Moore M. S. Keller
H. G. Saunders

Engineer Surveyor ... ... J. A. C. Graham

Electrical Engineer Surveyor ... H. G. Donald

BALTIMORE, Md.

Office: 1223-4, Munsey Building, Baltimore, 2.
Telephone No. Plaza 2411.
Telegrams: Surveyor.

Ship Surveyors ... ... J. G. Buchanan
R. Lyle

Ship and Engineer Surveyors ... C. B. McGhee
C. H. Haman

Engineer Surveyor ... ... A. V. Riise-Madsen

BOSTON, Mass., *including Providence, R.I., and Bath.*

Office: Room 927, 131, State Street, Boston, 9.
Telephone No. Hubbard 8674.
Telegrams: Surveyor.

Ship and Engineer Surveyor ... *Thomas Barrie

CHICAGO, Ill. (*See under* CLEVELAND).

CLEVELAND, Ohio, *including Buffalo, Detroit and Chicago.*

Office: Room 560, Rockefeller Building, Cleveland, 13.
Telephone No. Main 3910.
Telegrams: Lloyds.

Ship and Engineer Surveyor ... R. S. Haagensen

GALVESTON, Texas, *including all ports in Texas and Lake Charles, La.*

Office: Room 707, American National Insurance Building, Galveston.
Telephone No. 2-2832.
Telegrams: Register.

Ship and Engineer Surveyor ... J. Findlay

JACKSONVILLE, Fla., *including Charleston, S.C., Savannah, Ga., Miami, Key West and Tampa, Fla.*

Office: Room 518, Atlantic National Bank Building, Jacksonville, 2.
Telephone No. 5-1706.
Telegrams: Whist.

Ship and Engineer Surveyor ... *W. H. Stewart

LOS ANGELES, Cal., *including Long Beach and San Diego.*

Office: 119½, Anaheim Boulevard, Wilmington, Cal. (P.O. Box 575).
Telephone No. Terminal 4-2334.
Telegrams: Lloyds, Wilmington, Cal.

Ship and Engineer Surveyor ... W. J. Bloomfield

MOBILE, Ala., *including Pensacola, Fla.*

Office: Room 810, Mercharts National Bank Building, Mobile, 11.
Telephone No. 2-4882.
Telegrams: Register.

Ship and Engineer Surveyor ... W. F. Chapman

NEW ORLEANS, La.

Office: Room 821, Whitney Building, New Orleans, 12, La.
Telephone No. Raymond 8998.
Telegrams: Ships.

Ship and Engineer Surveyor ... *J. A. Laing

NEWPORT NEWS, Va., *including Norfolk and Richmond, Va., and Wilmington, N.C.*

Office: C. & O. Terminal Building, Newport News (P.O. Box 558).
Telephone No. 5-1661.
Telegrams: Register.

Ship and Engineer Surveyor ... J. Sim

Engineer Surveyor ... ... W. D. Wardle

PHILADELPHIA, Pa.

Office: Room 410. 1420, Walnut Street, Philadelphia 2, Pa.
Telephone No. Pennypacker 5-8764, 8765.
Telegrams: Surveyors.

Ship Surveyors ... ... R. G. S. Kennedy, B.Sc.
L. R. Chapman

Ship and Engineer Surveyors ... W. H. Runham
S. Smyth

Surveyor for Steel-testing duties J. K. Helms

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SURVEYORS—PORTS ABROAD—*continued.*

PITTSBURGH, Pa., *including Columbus, Canton, Youngstown and districts south thereof in Ohio.*

Office: Room 2001-A, Law & Finance Building, Pittsburgh, 19.
Telephone No. Atlantic 1-8958.
Telegrams: Register.

Surveyor for Steel-testing duties J. M. Grove, B.Sc.

PORTLAND, Or. (*See under* SEATTLE.)

QUINCY, Mass. (*See under* NEW YORK.)

Ship Surveyor ... ... W. M. Palmer

SAN FRANCISCO, Cal., *including Stockton, Cal.*

Office: Rooms 1233-34 & 1236, Matson Building, 215, Market Street, San Francisco, 5.
Telephone No. Douglas 0823.
Telegrams: Freeboard.

Ship and Engineer Surveyor ... E. Marlborough

SEATTLE, Wash., *with Tacoma, Bellingham, Grays Harbor and all ports in Washington territory; not including the Washington shore of the Columbia River; also Portland, Or.*

Office: Dexter Horton Building, Seattle, 4.
Telephone No. Elliott 8118.

Ship and Engineer Surveyor ... *J. F. Robertson

NETHERLANDS ANTILLES.

ARUBA, *including Lake Maracaibo.*

Office: P.O. Box 175, San Nicolas, Aruba, N.A.
Telephone No. 3181.
Telegrams: Register, Aruba.

Ship and Engineer Surveyor ... W. S. Holness

CURACAO.

Office: Handelskade 6, Willemstad; P.O. Box 169, Curaçao.
Telephone No. 2384.
Telegrams: Register.

Ship and Engineer Surveyor ... C. H. Westbury

PANAMA CANAL ZONE.

BALBOA, *with a district including all ports in the Panama Canal Zone.*

Office: 218, Pacific Terminal Building, Balboa; P.O. Box 304.
Telephone No. 1831.
Telegrams: Register, Balboa.

Ship and Engineer Surveyor ... W. C. Cowin

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SURVEYORS—PORTS ABROAD—*continued.*

CANADA

JOINT PRINCIPAL SURVEYORS FOR CANADA ... ... N. DOBSON
E. R. MACMILLAN

OFFICE: 231, ST. JAMES STREET, WEST, MONTREAL, P.Q. TELEGRAMS: *Register.*

HALIFAX, N.S.

Office: 37, Furness Withy Building, Halifax.
Telephone No. Bishop 7506.
Telegrams: Lloyd, Halifax, N.S.

Ship Surveyor ... ... R. M. Scott
Ship and Engineer Surveyors ... T. Laurie
G. Peddie

MONTREAL AND QUEBEC, *with a district including the River St. Lawrence.*

Office: 231, St. James Street West, Montreal, P.Q.
Telephone No. Marquette 6386.
Telegrams: Register.

Joint Principal Surveyors for Canada ... ... N. Dobson
E. R. Macmillan
Ship Surveyors ... ... H. L. Walker
A. Pullin
R. D. Campbell
(Resident at Quebec)
Engineer Surveyors ... ... W. Nicholson
L. M. Mathers
Ship and Engineer Surveyors ... D. J. Archibald
D. Halkett
(Resident at Quebec)

SAINT JOHN, N.B.

Office: 147, Prince William Street, P.O. Box 658, St. John, N.B.
Telephone No. 3-2789.
Telegrams:

Ship and Engineer Surveyor ... W. Heatlie

ST. JOHN'S, Newfoundland.

Office: Kings Wharf Building, St. John's.
Telephone No. 1697M.
Telegrams: Surveyor.

Ship and Engineer Surveyor ... R. A. Harvey

SYDNEY, N.S.

Office: care Dominion Steel & Coal Corp., Ld.
Telegrams: care Dominsteel.

Ship and Engineer Surveyor ... *Wm. Gilroy

TORONTO, Ont., *with a district including all ports on the Canadian side of the Great Lakes from Kingston, Ont., to Port Arthur, Ont., inclusive.*

Office: Room 407, Excelsior Life Building, 36, Toronto Street, Toronto, 1.
Telephone No. Elgin 8617.
Telegrams: Seaworthy.

Engineer Surveyors ... ... L. D. MacBean
J. Stevenson
Ship and Engineer Surveyor ... John Stephen
Ship Surveyor ... ... T. L. Millar

Sub-Office at **PORT ARTHUR, Ont.**

Office: 277, Argyle Street, Port Arthur, Ont.

Ship and Engineer Surveyor ... J. Macdonald

VANCOUVER AND VICTORIA, B.C., *including Vancouver Island, and all ports in British Columbia.*

Office: 1718, Marine Building, Vancouver, B.C.
Telephone No. Pacific 5188.
Telegrams: Registrar.

Ship and Engineer Surveyors ... R. Rennie, M.B.E.
J. A. Stewart
R. Chalcraft

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SURVEYORS—PORTS ABROAD—*continued.*

BRITISH WEST INDIES.

KINGSTON, Jamaica.

Office: Royal Mail Building, Port Royal Street, Kingston.
Telephone No. 2930.
Telegrams: Edwat, Jamaica.

Ship and Engineer Surveyor ... *E. Watson.

PORT OF SPAIN, Trinidad.

Office: c/o G. F. Huggins & Co., Ld.
Telephone No. 7211.
Telegrams: Cubitt, care Huggins & Co., Port of Spain.

Ship and Engineer Surveyor ... *J. C. Cubitt

CUBA.

HAVANA.

Office: San Pedro 16, Apartado 1846, Havana.
Telephone No. M.-6908.
Telegrams: Tomholmes, Havana.

Ship and Engineer Surveyor ... *T. F. Holmes

SOUTH AMERICA.

BUENOS AIRES, *including all ports in Argentine.*

Office: Calle 25 de Mayo 158, Buenos Aires.
Telephone No. Avenida 2364.
Telegrams: Surveyors.

Ship and Engineer Surveyors ... W. Rennie
C. N. Thomas
Engineer Surveyor ... ... A. Craig

MONTEVIDEO.

Office: Calle Solis 1480, Montevideo.
(Casilla de Correo 524).
Telephone: 84-728.
Telegrams: Register, Montevideo.

Ship and Engineer Surveyor ... H. Taylor

RIO DE JANEIRO.

Office: Rua da Candelaria 80, 6th Floor; Caixa Postale 4481, Rio de Janeiro.
Telephone No. Norte 23.2523.
Telegrams: Surveyor, Rio de Janeiro.

Ship and Engineer Surveyor ... M. Caldwell

SANTOS.

Office: Rua 15 de Novembro, 184, Caixa Postal 320.
Telephone: 2-3450.

Ship and Engineer Surveyor ... *G. Levi

TALCAHUANO, Chile, *with a district extending from Talca in the north to Chiloe in the south.*

Office: Avda. P. de Valdivia, Talcahuano; Casilla 245.
Telephone No.
Telegrams: Lloydsreg, Talcahuano.

Ship and Engineer Surveyor ... *Capt. V. Espejo

VALPARAISO, Chile.

Office: Casilla 148, Valparaiso.
Telephone No. 4604.
Telegrams:

Ship and Engineer Surveyor ... C. R. Rowcliffe

AFRICA.

EGYPT AND RED SEA.

ADEN.

Office: Hedjuff, Aden.
Telephone No. Hedjuff 409.
Telegrams: Lloydsur.

Ship and Engineer Surveyor ... *J. R. Fullick

ALEXANDRIA.

Office: "Al Bassir" Building, 5, Rue Adib Bey Isaac, Alexandria
Telephone No. 25088. (P.O. Box 740.)
Telegrams: Register.

Ship and Engineer Surveyor ... C. R. Maplestone

PORT SAID and SUEZ.

Office: Ground Floor, A. Marin Building, 36, Chareh Sultan Hussein, Port Said.
Telephone No. 2686.
Telegrams: Register.

Ship and Engineer Surveyor ... J. de Wolf

NORTH AFRICA.
ALGERIA AND TUNISIA.

ALGIERS.

Office: 28, Boulevard Carnot, Algiers.
Telephone No. 300-66.
Telegrams: McDonald c/o Charbonacco, Algiers.

Ship and Engineer Surveyor ... *G. M. McDonald

NIGERIA.

LAGOS.

Office: Kakawa House, Kakawa Street, Lagos.
Telephone: 920.
Telegrams: Lloydsreg, Lagos.

Ship and Engineer Surveyor ... J. White

SOUTH AND EAST AFRICA.

Senior Surveyor for South and East Africa ... ... P. F. Balfour (at Durban)

CAPE TOWN.

Office: 104, Commonwealth Building, Adderley Street, Cape Town.
Telephone No. 2-4493.
Telegrams: Lloydsreg.

Ship and Engineer Surveyor ... J. A. van Lare

DURBAN.

Office: 23/24, Cato House, 340, Smith Street, Durban; P.O. Box 170.
Telephone No. 24092.
Telegrams: Lloydsreg, Durban.

Ship and Engineer Surveyor ... P. F. Balfour (*Senior Surveyor for South and East Africa*)
Engineer Surveyor ... ... P. F. H. Brebner

MOMBASA.

Office: c/o Smith, Mackenzie & Co. P.O. Box 120, Mombasa.

Ship and Engineer Surveyor ... D. Ross Innes

PORT ELIZABETH.

Office: 6, Villiers Road, Walmer, Port Elizabeth.
Telegrams: Donkin, Port Elizabeth.

Ship and Engineer Surveyor ... *A. Donkin

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ASIA.

ADEN.

ADEN (*See under* EGYPT AND RED SEA).

BURMA.

RANGOON.
Office: R.N.6 Mayo Marine Club (Post Box 827).
Ship and Engineer Surveyor ... *R. P. R. Taylor, M.B.E.

CEYLON.

COLOMBO.
Office: 19½, P.O. & B.I. Building, York Street, Colombo.
Telephone No. 3694.
Telegrams: Register.
Ship and Engineer Surveyor ... T. H. Noel

CHINA.

SHANGHAI, *including Woosung, Chinkiang and Nanking.*
Office: Jardines Building, 27, The Bund, Shanghai.
Telegrams: Register.
Telephone No. 13895.
Ship and Engineer Surveyor ...

TIENTSIN.
Office: 148, Chung Cheng Lu, Tientsin.
Telegrams: Seaworthy.
Ship and Engineer Surveyor ...

EAST INDIAN ARCHIPELAGO.

DJAKARTA.
Office: No. 6 Djalan de Riemer, Djakarta, Indonesia.
Telegrams: Register.
Engineer Surveyor ... ... W. Boone

MACASSAR.
Address:
Telegrams:
Ship and Engineer Surveyor ...

MANILA, P.I., *and ports in the Philippine Islands.*
Office: 240, Dasmarinas, Manila.
Telephone No. 2-71-52.
Telegrams: Register.
Ship and Engineer Surveyor ... *C. B. Nelson

SOURABAYA.
Office: Marine Etablissement, Sourabaya, Java.
Telegrams: Surlind, Sourabaya.
Ship and Engineer Surveyor ... *Eng.-Comdr. C. van der Linden

HONG KONG.

HONG KONG.
Office: Shell House, Queen's Road, Hong Kong.
Telephone:
Telegrams: Marine.
Ship and Engineer Surveyors ... J. A. Anderson
F. B. Gill
C. Ritchie

INDIA.

Senior Surveyor for India ... ... J. Rundle

BOMBAY.
Office: Laxmi Building, Ballard Road, Bombay, India.
Telephone No. 23335.
Telegrams: Surveyor.
Ship and Engineer Surveyor ... J. Rundle
(Senior Surveyor for India)
Engineer Surveyor ... ... J. F. James

CALCUTTA.
Office: 9, Netaji Subhas Road, Calcutta, India.
Telephone No.: Bank 7182.
Telegrams: Freeboards.
Ship and Engineer Surveyors ... R. E. Pritchard
E. Grieves
Ship Surveyor ... ... A. P. Moore

MADRAS.
Telephone: 2965 Office, 3461 Residence.
Office: c/o Port Trust, Madras, S. India.
Telegrams: Cooper, Port Trust, Madras.
Ship and Engineer Surveyor ... *F. G. Cooper

SINDRI BIHAR.
Office: Care Power-Gas Corporation, Ld., Sindri P.O. Manbhur District Bihar.
Engineer Surveyor ... ... F. H. McD. Wilson

VIZAGAPATAM.
Office: P.O. Box 109, Vizagapatam Port, Vizagapatam, S. India.
Telephone: 56.
Telegrams: Surveyor, Vizagapatam.
Ship Surveyor ... ... T. S. Fatkin

JAPAN.

Senior Surveyor for Japan ... A. E. Munro
(at Kobe)

KOBE.
Office: Chartered Bank Building, 9, Kaigan-dori, Ikuta-ku (P.O. Box 446), Kobe.
Telegrams: Register.
Ship and Engineer Surveyors ... A. E. Munro
(Senior Surveyor for Japan)
R. Rodger
D. Currie
L. T. Williams
M. Kamakura
Ship Surveyors ... ... R. Ibison
G. G. Young
Surveyors for Steel-testing duties M. Ogawa
A. Murao

YOKOHAMA.
Office: 7, Yamashita-Cho, Naka-ku (P.O. Box 228), Yokohama.
Telegrams: Register, Yokohama.
Ship and Engineer Surveyors ... P. W. Mason
Y. Hamada

MALAYA.

PENANG.
Office: Surveyor of Ships Office, Government Building, Beach Street, Penang, Federation of Malaya.
Telegrams: Surveyor of Ships, Penang.
Ship and Engineer Surveyor ... *W. G. Christie

PAKISTAN.

KARACHI.
Office: c/o Messrs. G. B. Potts & Co., Mercantile Bank Building, McLeod Road, Karachi, Pakistan.
Telephone: Karachi 2433.
Telegrams: Freeboard, Karachi.
Ship and Engineer Surveyor ... *J. Johnston

SINGAPORE.

Office: 2, Laidlaw Building, Battery Road, P.O. Box 480, Singapore.
Telephone: 2861.
Telegrams: Surveyor.
Ship and Engineer Surveyors ... J. Wormald, B.Sc.
R. Potts
W. P. Watson

SIAM.

BANGKOK.
Office: c/o Borneo Co., Ld., Bangkok.
Ship and Engineer Surveyor ... *N. A. Richardson

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SURVEYORS—PORTS ABROAD—*continued.*

AUSTRALIA.

PRINCIPAL SURVEYOR FOR AUSTRALIA ... ... H. A. GARNETT (at Sydney)

ADELAIDE, S.A.

Office: Institute Chambers, Divett Street, Port Adelaide.
Telephone No. Y.1547.
Telegrams: Dinwoodie.

Ship and Engineer Surveyor ... *C. E. Hall

BRISBANE (Queensland).

Office: Orient Line Building, Eagle Street, Brisbane.
Telephone No. 4189.
Telegrams: Register.

Ship and Engineer Surveyor ... J. E. North

FREMANTLE, W.A.

Office: 21, Phillimore Street, Fremantle, P.O. Box. 16.
Telephone No. 2699.
Telegrams: Mardav.

Ship and Engineer Surveyor ... *W. G. Davies

MELBOURNE (Victoria).

Office: New Zealand Chambers, 483, Collins Street, Melbourne.
Telephone No. M.B.2486.
Telegrams: Reports.

Ship and Engineer Surveyor ... P. A. McIntyre
Engineer Surveyors ... ... J. E. Thompson
J. S. Irvine

NEWCASTLE, N.S.W.

Office: Howard Smith Chambers, 14, Watt Street, Newcastle; P.O. Box 538, Newcastle.
Telephone No. B3078.
Telegrams:

Ship and Engineer Surveyor ... W. B. C. Elder
Engineer Surveyor ... ... E. G. Hughes

SYDNEY, N.S.W.

Office: 4, Bridge Street, Sydney.
Telephone No. B.W.7023-Automatic.
Telegrams: Miramar.

Ship and Engineer Surveyors ... H. A. Garnett (*Principal Surveyor for Australia*)
B. P. Fielden
A. McBurney
F. K. L. Birk
J. H. Cowell
H. Gerrard

Engineer Surveyor ... ... W. H. Gregory, D.S.C., M.A.

WHYALLA.

Office: c/o Shipyard, The Broken Hill Proprietary Co., Ld., Whyalla.

Ship Surveyor ... ... W. C. Millar, B.Sc.

NEW ZEALAND.

SENIOR SURVEYOR FOR NEW ZEALAND ... ... W. KIMBER (at Wellington)

AUCKLAND, N.Z.

Office: 63, Endeans Buildings, Queen Street, Auckland.
Telephone No. 43-163.
Telegrams: Somisto.

Ship and Engineer Surveyor ... *W. Richard Smith

CHRISTCHURCH & LYTTELTON, N.Z.

Office: 154-156, Hereford Street, P.O. Box 1171.
Telephone No. 37-527 (Residence), 40-123 (Office).
Telegrams: Oileng.

Ship and Engineer Surveyor ... *E. P. Combellack

DUNEDIN, N.Z.

Office: Colonial Mutual Assurance Buildings, 276, Princes Street, Dunedin, C.I. P.O. Box 904.
Telephone No. 10-672.
Telegrams: Cellular.

Ship and Engineer Surveyor ... *G. W. Martin

LYTTELTON, N.Z. (*See under* CHRISTCHURCH, N.Z.)

WELLINGTON, N.Z.

Office: Nathans Buildings, Wellington; G.P.O. Box 996.
Telephone No. 43-624.
Telegrams; Lloydsreg, Wellington.

Ship and Engineer Surveyors ... W. Kimber
J. Davidson

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RULES AND REGULATIONS

RELATING TO THE

ADMINISTRATION OF THE SOCIETY,

TERMS OF SUBSCRIPTION TO THE REGISTER BOOK,

DUTIES OF SURVEYORS, &c.

LLOYD'S REGISTER OF SHIPPING.

RULES AND REGULATIONS.

Section 1.

THIS Society, founded in 1760 and reconstituted in 1834, was established for the purpose of obtaining for the use of Merchants, Ship Owners, and Underwriters, a faithful and accurate Classification of Mercantile Shipping, and for the government of which the following Rules and Regulations have been from time to time adopted.

Section 2.

A Register Book to be printed annually for the use of Subscribers, containing the names of the Ships with other useful information, and the Character assigned, where the ships are classed by the Society; also the names, &c., of all Ships of 100 tons and upwards unclassed by this Society.

Section 3.

Each person subscribing the sum of Twelve Guineas per annum (or such other sum as the General Committee may fix) to be considered a Member of the Society, and entitled *for his own use* to one copy of the Register Book.

Section 4.

The Subscription of Public Institutions to be Twenty Guineas per annum unless the copies be periodically posted with type with additions and corrections throughout the year, in which case the subscription for each copy supplied will be Thirty Guineas per annum.

Section 5.

In the case of all other Subscribers, including Marine Insurance Companies, the subscription to be Twelve Guineas per annum for each copy, unless periodically posted with type with additions and corrections throughout the year, in which case the subscription will be Twenty-five Guineas per annum for each copy supplied.

Section 6.

For the convenience of subscribers not resident in London, or whose Register Books are not posted, a Supplement, containing the additions to, and corrections made in, the Register Book to be printed fortnightly, in such convenient form as to admit of its transmission by post, so that such parties may be furnished, from time to time, with the latest and most complete information.

Section 7.

The superintendence of the affairs of the Society to be under the direction of a General Committee composed of Merchants, Ship Owners, and Underwriters (twenty-four elected in London, namely, nine by the Committee of Lloyd's, twelve by the Committee of the London General Shipowners' Society, and three by the Committee of the Institute of London Underwriters, and thirty-seven at the principal Outports), and the following, namely:—Shipbuilders and/or Engineers, not exceeding ten, who may be elected by the General Committee; additional Members not exceeding twelve, who may be elected by the General Committee; past Chairmen, Deputy-Chairmen and Treasurers, and Deputy-Chairmen and Chairmen of Classification of the Society, who may be elected by the General Committee, and the following *ex-officio* members, namely:—The Chairman, or, in his absence, the Deputy-Chairman, of the Corporation of Lloyd's; the Chairman, or, in his absence, the

Deputy-Chairman, of the London General Shipowners' Society; the Chairman, or, in his absence, the Deputy-Chairman, of the Institute of London Underwriters, and the Chairman of each Branch Committee established abroad.

Any member (except an *ex-officio* member, or a member elected by the General Committee) who fails to attend any meetings of the General Committee for a period of six consecutive months, without leave of absence, shall cease to be a member, and his place shall be filled up in the usual way.

NOTE.—Official intimation to be given in June of each year whether the Chairman or Deputy-Chairman of the Corporation of Lloyd's, the Chairman or Deputy-Chairman of the London General Shipowners' Society, and the Chairman or Deputy-Chairman of the Institute of London Underwriters, are to be the *ex-officio* members for the ensuing twelve months.

Section 8.

The General Committee reserve the right of varying or withdrawing the representation of Outports, and of Shipbuilders and Engineers; also the representation of Shipbuilders, Engineers, Steel Makers, and Forgemasters on the Technical Committee hereinafter mentioned, as well as the mode of election of members.

Section 9.

1. Seven of the Members elected in London, namely, three representatives of Lloyd's, three representatives of the London General Shipowners' Society, and one representative of the Institute of London Underwriters, to retire annually by rotation, but to be eligible for re-election. The vacancies so arising to be filled by the election of three representatives by the Committee of Lloyd's, three representatives by the Committee of the London General Shipowners' Society, and one representative by the Committee of the Institute of London Underwriters.

2. Of the Members elected at the Outports twenty-one to retire at the end of four years, and seven of the Members elected at Liverpool and the nine Members elected at Glasgow to retire annually. The retiring Members are eligible for re-election.

3. All Members elected by the General Committee are to retire at the end of four years, and are to be eligible for re-election.

Section 10.

The Committee to appoint Sub-Committees of Classification, to be so regulated that each Member of the General Committee may, in rotation, take his turn of duty thereon throughout the year.

Section 11.

The Committee to appoint from their own body, annually, a Chairman and two Deputy-Chairmen; one being designated Deputy-Chairman and Treasurer and the other Deputy-Chairman and Chairman of the Sub-Committees of Classification.

Section 12.

The Secretary, Clerks, and Servants of the Society, and the Surveyors, to be appointed by and be under the direction of the General Committee.

Section 13.

Special meetings to be convened by order of the Chairman, or one of the Deputy-Chairmen, or on the requisition of any three Members.

Section 14.

All elections and appointments to be made by ballot, excepting when in the election of Chairman, or one of the Deputy-Chairmen, only one person is nominated for each office.

Section 15.

No Member of the Committee to be permitted to be present on the decision of the classification of any ship of which he is the owner, or wherein he is directly, or indirectly, interested.

Section 16.

1. The Committee to be empowered to make such By-laws for their own government and proceedings as they may deem requisite, not being inconsistent with the original Rules and Regulations under which the Society was established; but no new Rule or By-law to be introduced or any Rule or By-law altered, without special notice being given for that purpose at the Meeting of the Committee next preceding that at which such Motion is intended to be made; such notice to be inserted in the summons convening the meeting.

2. No new Rule, or alteration in any existing Rule materially affecting the classification of ships, to be applied compulsorily to ships of which the plans have been submitted and approved before the expiration of six months after the date when the change has been adopted.

Section 17.

TECHNICAL COMMITTEE.

1. The Technical Committee to be constituted as follows:—

Ex-officio—	Ship Owners.	Under-writers.	Ship-builders.	Engineers.	Others.	TOTAL.
The Chairman of Lloyd's Register	1	–	–	–	–	1
The Deputy-Chairman and Treasurer of Lloyd's Register	–	1	–	–	–	1
The Deputy-Chairman and Chairman of Sub-Committees of Classification ...	1	–	–	–	–	1
Nominated by—						
The General Committee of Lloyd's Register	5	3	2	2	–	12
The Institution of Naval Architects ...	–	–	1	1	–	2
The North-East Coast Institution of Engineers and Shipbuilders	–	–	1	1	–	2
The Institution of Engineers and Shipbuilders in Scotland	–	–	1	1	–	2
The Shipbuilding Conference	–	–	5	–	–	5
The National Association of Marine Engine-builders	–	–	–	3	–	3
The Institute of Marine Engineers	–	–	–	1	–	1
The Society of Consulting Marine Engineers and Ship Surveyors	–	–	–	1	–	1
The Dry Dock Owners' and Repairers' Central Council	–	–	–	–	2	2
The Iron and Steel Institute	–	–	–	–	1	1
The British Iron and Steel Federation ...	–	–	–	–	1	1
The National Forgemasters' Association ...	–	–	–	–	1	1
The Honourable Company of Master Mariners	–	–	–	–	1	1
The Institution of Electrical Engineers ...	–	–	–	–	1	1
The British Electrical and Allied Manufacturers' Association	–	–	–	–	1	1
The Technical Committee	3*	–	2	2	–	7
Representatives of Branch Committees of Lloyd's Register abroad	–	–	–	–	5	5
*Superintendents.	10	4	12	12	13	51

The above nominations to be subject to confirmation by the General Committee.

2. The function of the Technical Committee is to consider any technical problems connected with the Society's business, and any proposed alterations in the existing Rules, or frame new Rules, for the classification, survey and building of ships and machinery.

3. The term of office of all members to be four years, one-fourth retiring each year, the members so retiring to be eligible fo renomination for a second term. No member, other than the Chairman and/or Vice-Chairmen, who has served for two periods of four years to be eligible for renomination for a third term until after the expiration of at least one year. In the event of any vacancy occurring before the expiration of a term of four years a representative to be nominated to fill the vacancy for the unexpired portion of the term.

4. With the exception of the Superintendents nominated by the Technical Committee, only those who are actually partners in firms, or directors or managers of joint stock companies, or of similar status, to be eligible for membership.

5. The Technical Committee to appoint from their own body, biennially, a Chairman, who must be a member of the General Committee, and, if desired, two Vice-Chairmen, who need not be members of the General Committee. The same members to be not eligible to hold office for more than four years in succession, unless on the occasion of the third election a ballot—to be taken whether there be any other candidates or not—shows a majority in their favour of at least three-fourths of the members present. The appointment of Chairman and of Vice-Chairmen to be confirmed by the General Committee.

6. Meetings of the Technical Committee to be convened as often and at such times and places as may appear necessary, but there shall be at least three meetings in each year.

7. Members desiring to propose alterations in, or additions to, the Rules for the classification, survey or building of ships and machinery shall give notice of all such proposals in writing to the Secretary.

Every meeting to be convened by notice from the Secretary, if possible one month before the date of meeting; and the Secretary to send to each member an agenda paper as soon as possible thereafter.

8. Any proposal of the Technical Committee involving any amendment of, or addition to, the Rules for the classification, survey or building of ships and machinery to be reported to the General Committee, who will refer them to a Special Meeting of the General Committee, as required by Section 16 of the Rules.

9. The Technical Committee to be empowered:—

(i) to draw up, if they so desire, by-laws for governing procedure at meetings;

(ii) to appoint Panels of the Committe ;

(iii) to co-opt to the main Committee, or to such Panels, representatives of any organisation or industry or private individuals for the purpose of considering any particular problem.

10. The General Committee reserve to themselves the right of varying, adding to, or rescinding, at their discretion, any or all the foregoing Rules.

Section 18.

All Reports of survey to be made in writing by the Surveyors according to the form prescribed, and submitted for the consideration of the General Committee, or of the Sub-Committees of Classification; but the character assigned by the latter to be subject to confirmation by the General Committee.

Section 19.

1. The reports of the Surveyors (and all documents and proceedings relating to the classification of ships) are to be carefully preserved and shall, subject to the approval, in his absolute discretion, of the Chairman, or one of the Deputy-Chairmen, be open to the inspection of the Owner and of any other person authorised in writing by the Owner.

Copies of reports will, subject to the approval of one of the Chairmen as indicated above, be supplied to Owners, or their representatives, on application.

Section 20.

The Surveyors to the Society not to be permitted (without the especial sanction of the Committee) to receive any fee, gratuity, or reward whatsoever for their own use or benefit, for any service performed by them in their capacity of Surveyors to this Society, on pain of immediate dismissal.

Section 21.

While the Committees of the Society use their best endeavours to ensure that the functions of the Society are properly executed, it is to be understood that neither the Society nor any Member of any of its Committees is under any circumstances whatever to be held responsible for any inaccuracy in any report or certificate issued by the Society or its Surveyors, or in any entry in the Register Book or other publication of the Society, or for any error of judgment, default or negligence of any of its Committees or any Member thereof, or the Surveyors, or other Officers or Agents of the Society.

Section 22.

The Funds and Accounts to be under the authority and control of the Committee.

Section 23.

Fees are chargeable for all surveys held by the Society's Surveyors at ports in the United Kingdom in accordance with established scales.

For all surveys held at ports abroad a fee will be chargeable according to the nature and extent of the services rendered.

Travelling expenses incurred by the Surveyors in connection with the above services are also chargeable.

Section 24.

The class of a ship is liable to be withheld, or, if already granted, may be withdrawn or expunged from the Register Book in the case of non-payment of any fees or expenses chargeable on account of such ship.

71, Fenchurch Street, London, E.C.3.

16th December, 1948.

GENERAL REGULATIONS

FOR THE

CLASSIFICATION OF STEEL SHIPS

AND THEIR

MACHINERY

PERIODICAL SURVEY REQUIREMENTS

INDEX

GENERAL REGULATIONS FOR THE CLASSIFICATION OF STEEL SHIPS AND THEIR MACHINERY.

	Section.	Clause.	Page.
A			
Appeal from Surveyors' Recommendations	—	11	13
B			
Build, date of	—	6(*e*)	11
	—	8(*b*)	11
C			
Certificate, class	—	13(*a*)	13
„ provisional	—	13(*b*)	13
Class, 100A	—	1(*b*)	9
„ 100A "Carrying Petroleum in Bulk"	—	1(*e*)	9
„ 100A "For Restricted Service" ...	—	1(*d*)	9
„ 100A "For Special Service" ...	—	1(*c*)	9
„ A "For Restricted Service" ...	—	1(*f*)	10
„ expunging with black line ...	—	14(*c*)	14
„ „ „ red line	—	14(*b*)	14
„ withdrawal of	—	14(*a*)	14
„ „ for infringement of Freeboard ...	—	14(*d*)	14
Classification, assignment of	—	1(*a*)	9
„ „ machinery ...	—	3	10
„ „ ships not built under Survey	—	7	11
Construction, materials to be used ...	—	4	10
„ new	—	6	10
„ novel forms of	—	6(*c*)	11
E			
Equipment	—	2	10
Equivalent Arrangements	—	5	10
P			
Plans, submission of	—	6(*a*)	10
R			
Register Book, notation in	Section.	Clause.	Page.
„ „ Ice strengthening	—	1(*h*)	10
„ „ novel forms of construction ...	—	6(*c*)	11
„ „ other notations ...	—	1(*i*)	10
„ „ special cargoes ...	—	1(*g*)	10
„ records in—Survey under construction ...	—	3,6(*d*)	10,11
„ „ special surveys ...	—	8(*d*)	12
„ „ progressive surveys	—	8(*i*)	12
Repairs and Alterations, notice of ...	—	10(*a*)	13
„ survey of	—	10(*b*)	13
Rules, deviation from	—	5	10
S			
Ships, loading of	—	6(*b*)	11
„ reclassification of	—	15	14
Survey, ships not built under, classification of	5	—	25
Surveys, annual	—	8(*a*)	11
„ boilers and screw shafts ...	—	8(*h*)	12
„ continuous, of oil engines ...	—	8(*g*)	12
„ modified, „ „ ...	—	8(*f*)	12
„ notice of	—	12	13
„ occasional	—	8(*a*)	11
„ of repairs and alterations ...	—	10	13
„ periodical	—	8	11
„ „ requirements—annual or occasional	1	—	15
„ „ „ Hull ...	2	—	16
„ „ „ Machinery	4	—	20
„ „ „ Ships not built under Survey	5	3	26
„ petroleum tankers	3	—	20
„ progressive (and of oil tanks) ...	—	8(*i*)	12
„ refrigeration	—	9	13
„ special	—	8(*b*)	11
„ „ during construction ...	—	6(*d*)	11
„ „ held in anticipation ...	—	8(*c*)	12
„ „ machinery	—	8(*e*)	12
„ „ period allowed for completion	—	8(*c*)	12
„ „ record of	—	8(*d*)	12

INDEX

GENERAL REGULATIONS

FOR THE

CLASSIFICATION OF STEEL SHIPS

AND THEIR

MACHINERY.

1. Classification. (*a*) *General.*—Steel ships built in accordance with the Society's Rules and Regulations, or with alternative arrangements equivalent thereto (*see* Clause 5), will be assigned a class in the Register Book and will continue to be classed so long as they are found, upon examination at the prescribed annual and periodical surveys, to be maintained in such fit and efficient condition as is prescribed by the Society's Rules for the safe carriage of dry and perishable or other approved cargoes.

In cases where the scantlings and arrangements have been approved by the Committee for stipulated cargoes of a special nature, a notation indicating the nature of such cargo may be entered in the Register Book.

Classification will be conditional upon compliance with the Society's requirements in respect of both hull and machinery (*i.e.,* main and auxiliary engines, boilers, essential appliances, pumping arrangements and electrical equipment).

(*b*) *Class* 100A.—This class will be assigned to all sea-going ships built in accordance with, or by standards equivalent to, the Society's Rules and Regulations and the scantlings given therein for the draught required.

(*c*) *Class* 100A *"For Special Service."*—This class will be assigned to sea-going ships intended for special services and built in accordance with, or by standards equivalent to, the Society's Rules and Regulations and the practice and standards of the Committee for such ships. The notation affixed to the class in the Register Book will indicate the particular service for which the ship is approved, *e.g.,* "Dredger," "Hopper Barge," "For Towing Services."

(*d*) *Class* 100A *"For Restricted Service."*—This class will be assigned to sea-going ships intended to trade within specified limits and built in accordance with the Society's Rules and Regulations and the scantlings and arrangements approved by the Committee for the intended service. The notation affixed to the class in the Register Book will indicate the particular service for which the ship is approved, *e.g.,* "For Coasting Service," "For Channel Service," and the geographical limits of the service will be defined.

(*e*) *Class* 100A *"Carrying Petroleum in Bulk."*—This class will be assigned to ships built in accordance with, or by standards equivalent to, the Society's Rules and Regulations and the scantlings and arrangements given in the relevant sections of the Rules.

Where the scantlings and arrangements have been approved by the Committee for the carriage of other liquid cargoes in bulk the notation affixed to the class may be suitably modified.

(*f*) *Class* A *"For Restricted Service."*—This class will be assigned to ships intended to trade within specially sheltered limits such as harbours, rivers or estuaries, provided the scantlings and arrangements are approved by the Committee as suitable for such service. A notation will be affixed to the class indicating the particular service for which the ship has been approved.

(*g*) *Special Cargoes.*—In dry cargo ships, any compartments intended for the carriage of liquid cargoes, such as vegetable or mineral oils having a flash point above 150° F., are to be in accordance with the requirements of the Rules relating thereto; in such cases, an appropriate notation will be entered in the Register Book.

(*h*) *Ice Strengthening.*—Where the notation "Strengthened for Navigation in Ice" is desired, additional strengthening is to be fitted in accordance with the special requirements given in the Rules.

(*i*) *Other Notations.*—Descriptive notations may be made in the Register Book when deemed necessary by the Committee to indicate any special features in the design or construction of a ship or machinery.

2. Equipment.—The figure **1** placed after the character of classification assigned to a ship indicates that her equipment of anchors, chain cables and hawsers is in good and efficient condition and, in the case of ships not classed for a special or restricted service, that they are in accordance with, or of a standard equivalent to, the requirements set forth in the Rules. In the case of ships classed for a special or restricted service, the figure 1 indicates that the equipment has been approved by the Committee as suitable for that particular service.

When the equipment of a ship is not supplied or maintained in accordance with, or of a standard equivalent to, the requirements of the Rules, or as approved by the Committee for a particular service, the figure 1 will be omitted and a line inserted after the character of classification thus: 100A–. In such cases, the Committee will require to be advised of the equipment actually supplied; and if this is found to be seriously deficient in quantity or quality, the class of the ship will be liable to be withheld or expunged from the Register Book.

3. Machinery.—The machinery, as defined in **Clause 1** (*a*), is to be constructed and installed on board ship in accordance with the Society's Rules and Regulations. On satisfactory completion of trials, appropriate notations and records *in red* will be assigned in the Register Book, *e.g.*, LMC11,49 (Lloyd's Machinery Certificate 11,49), NE&B11,49 (New Engines and Boilers 11,49), NE11,49 or NB11,49.

4. Materials.—The materials used in the construction of ships and their machinery intended for classification, or in the repair of ships already classed, are to be of good quality and free from defects and are to be tested under the supervision of the Society's Surveyors in accordance with the requirements of the Rules. The steel is to be manufactured by an approved process at works recognised by the Committee.

5. Equivalent arrangements.—Alternative arrangements to those prescribed in the Rules will be permitted, provided they are submitted to the Committee and considered by them to be equivalent to the Society's requirements. The Builders shall obtain the Owners' consent to such alternative proposals when the Committee deem this necessary.

6. New Construction. (*a*) *Submission of Plans.*—When it is intended to build a ship for classification in the Register Book, constructional plans and particulars of the hull, equipment and machinery (*see* **Clause 1** (*a*)), as detailed in the respective sections of the Rules, are to be submitted through the local Surveyors for the approval of the Committee before the work is commenced.

(*b*) *Loading of Ships.*—The scantlings and arrangements given in the Rules are not framed to provide for any special concentration of loading, and if such is contemplated the Committee may require additional strengthening to be fitted.

Where it is desired to make provision for exceptional ballast or loaded conditions, the necessary particulars are to be given on the plans when these are submitted for approval.

(*c*) *Novel Forms of Construction.*—Where the proposed construction of a ship or any part of her machinery is novel in design, or involves the use of unusual material, or where experience has, in the opinion of the Committee, not sufficiently justified the principle or mode of application involved, special tests or examinations before and during service may be required, and a suitable notation inserted in the Register Book when the Committee consider this necessary.

(*d*) *Special Survey during Construction.*—New ships intended for classification are to be built under the Society's Special Survey and when classed will be entitled to the distinguishing mark ✠ inserted before the character of classification in the Register Book thus: ✠100A.

New machinery for ships classed or intended for classification in the Register Book is to be constructed under the Society's Special Survey, and on completion will be entitled to the distinguishing mark ✠ *in red* inserted before the machinery records in the Register Book, thus: ✠LMC, ✠NE, ✠NB.

During the construction, from the commencement of the work until the completion of the ship and final test of the machinery under working conditions, the Surveyors are to examine the materials and workmanship and are to indicate, and require the rectification of, any items not in accordance with the Rules or the approved plans, or of any material, workmanship or arrangement found to be defective or unsatisfactory.

(*e*) *Date of Build.*—The date of completion of the Special Survey during construction of ships built under the Society's inspection will normally be taken as the date of build to be entered in the Register Book. If, however, the period between launching and completion or commissioning is, for any reason, unduly prolonged, the dates of launching and completion or commissioning may be separately indicated in the Register Book.

In any case in which a ship upon completion is not immediately put into commission, but is laid up for a period, the Committee, upon application by the Owner, prior to the ship proceeding to sea, may direct an examination of the ship to be made in dry dock by the Society's Surveyors. If, as the result of such survey, the hull and machinery be reported in all respects free from deterioration, the subsequent Special Surveys will date from the time of such examination.

7. Classification of Ships not built under survey.—The requirements of the Committee for the classification of ships and their machinery which have not been built under the Society's survey are set forth in **Section 5, Periodical Survey Requirements.**

8. Periodical Surveys. (*a*) *Annual or Occasional Surveys.*—All steel ships and their machinery are subject to Annual or Occasional Surveys in accordance with the requirements set forth in **Section 1, Periodical Survey Requirements.**

(*b*) *Special Surveys.*—To entitle ships to retain the class assigned to them in the Register Book, they are to be subjected to Special Surveys in accordance with the requirements set forth in **Sections 2 3 and 4 Periodical Survey Requirements.** These Surveys become due at 4-yearly intervals, the first 4 years from the date of build or date of Classification Survey, and thereafter 4 years from the date of the previous Special Survey.

(*c*) *Period allowed for completion of Special Surveys.*—When it is inconvenient for Owners to fulfil all the requirements of a Special Survey at its due date, part only of the survey need then be carried out, provided, in the case of the first Special Survey of new ships, the remainder of the survey be completed within 12 months from the due date, and, in the case of subsequent Special Surveys, the survey be completed within 6 months from that date.

Special Surveys which are commenced prior to their due date must not extend over a period greater than 12 months or beyond the times prescribed above.

(*d*) *Record of Special Surveys.*—Ships which have satisfactorily passed a Special Survey will have a notation entered in the Register Book indicating the date and place of such survey, thus: ssLon.11,49. For Special Surveys at which the prescribed requirements as to drilling of the shell plating have been complied with, the record will be entered thus: *ss*Lon.11,49(Dr.). Where a Special Survey is not completely carried out at one time, the date recorded in the Register Book will be the date at which the principal part of the requirements is complied with. Records of Special Survey will not be assigned until the Society's requirements for Machinery Special Surveys detailed in the following **Clauses** (*e*) or (*g*) are satisfactorily completed.

(*e*) *Special Surveys of Machinery.*—Machinery, as defined in **Clause 1** (*a*), is to be submitted to the Special Surveys set forth in **Section 4. Periodical Survey Requirements.** Such surveys are to be carried out coincidently with the special survey of the hull, unless the machinery has been specially surveyed within a period of 12 months. On satisfactory completion, appropriate notations *in red* will be entered in the Register Book, *e.g.*, ✠LMC11,49.

Where a Special Survey of the machinery is not completed at one time, the date recorded in the Register Book will be that on which the first portion of the survey is carried out.

(*f*) *Modified Surveys of Oil Engines.*—Modified Surveys of oil engine machinery as detailed in **Section 3, Periodical Survey Requirements,** are to be carried out as they become due, namely, 2 years from the last recorded Special Survey of Machinery. On satisfactory completion an appropriate notation *in red* will be made in the Register Book, *e.g.*, ✠LMC(M)11,49.

(*g*) *Continuous Surveys of Oil Engines.*—Where at the request of Owners it has been agreed to carry out the Special Survey of oil engine machinery on the Continuous Survey basis, approximately one quarter of the survey requirements should be fulfilled each year in rotation and the cycle should be completed coincidently with the Special Survey of the hull. In such cases, a record *in red* indicating the date of the completion of the cycle, and an underdate indicating that the required proportion of the cycle had been completed at that date, will be recorded, thus: ✠LMC $\frac{\text{CS11,48}}{11,49}$

(*h*) *Boiler and Screw Shaft Surveys.*—Boiler Surveys and Screw Shaft Surveys should be carried out as set forth in **Section 4, Periodical Survey Requirements.** On satisfactory completion, records *in red* such as BS11,48, or the date of the Screw Shaft Survey, will be entered in the Register Book.

(*i*) *Progressive Surveys.*—In the case of large passenger ships engaged on a regular service, when the size of ship or exigencies of the service render it difficult to carry out the Special Surveys at the times prescribed in the Regulations, the Committee will be prepared, at the request of the Owners, to consider and sanction suitable arrangements for a progressive survey of the hull or machinery. In such cases all compartments of the hull are to be progressively surveyed and tested, so that the survey cycle is completed during the period normally allowed by the Rules between Special Surveys, and the time which elapses between consecutive examinations and testing of each compartment is not to exceed that period. Similar arrangements are to be made in respect of the machinery.

On a similar basis, the Committee will be prepared to sanction the progressive survey and testing of the oil compartments of petroleum tankers.

Notations and records in respect of such progressive surveys will be made in the Register Book, and the Certificates of Classification endorsed as considered necessary by the Committee.

9. Refrigeration.—On the application of Owners of ships intended wholly or partially for the carriage of refrigerated cargoes, the Committee will authorise the Surveyors to survey the refrigerating machinery, appliances and insulation during construction and installation in accordance with Section 1 of the Society's Rules for Refrigerating Machinery and Appliances of Ships. On satisfactory completion, certificates of classification in respect of such appliances will be issued and an appropriate notation will be entered in the Refrigeration Section of the Register Book. The Committee will also be prepared to authorise the Surveyors to survey existing installations, and, provided the requirements of the Rules for such installations are complied with, a certificate will be issued and a notation assigned, but without the distinguishing mark ✠.

In order that the character assigned to the Refrigerating Machinery installation in the Register Book may be retained, the installation is to be subject to the Periodical and Loading Port Surveys set forth in Section 6 of the above Rules.

10. Repairs and Alterations.—(*a*) When the Surveyors consider repairs to be necessary, they will communicate their recommendations at once to the Owners, or their representative, and if compliance therewith cannot be arranged, a special report will be made as soon as possible to the Committee.

(*b*) All repairs to hull and machinery which may be required in order that a ship may retain her class in the Register Book, or any alterations affecting the approved arrangements, are to be carried out under the inspection of, and to the satisfaction of, the Society's Surveyor when one is stationed in the district. When such repairs or alterations are effected at a port where there is no Surveyor to this Society, the ship must be surveyed by one of the Society's Surveyors at the earliest opportunity.

11. Appeal from Surveyor's recommendations.—If the recommendations of the Society's Surveyors are considered in any case to be unnecessary or unreasonable, appeal may be made to the Committee, who may direct a special examination to be held.

12. Notice of Surveys.—Owners will be advised regarding the dates when Periodical Surveys on the hull and machinery become due.

The Society's Surveyors are required to attend for the purpose of holding surveys in their district, but the duty of giving notice when the attendance of the Surveyors is required to carry out periodical, special or other surveys, or to supervise repairs, rests with the Owners or their representatives.

13. Certificates of Class.—(*a*) When the required reports on completion of the Special Surveys of new ships, or of existing ships submitted for classification, have been received from the Surveyors and approved by the Committee, Certificates of first entry of classification in the Register Book, signed by the Chairman, Deputy-Chairman and Treasurer, or Deputy-Chairman and Chairman of the Sub-Committees of Classification, and countersigned by the Secretary, will be issued to Builders or Owners.

Certificates of class maintenance in respect of completed periodical surveys of hull and machinery will also be issued upon application.

(*b*) The Society's Surveyors are permitted to issue provisional certificates to enable a ship, classed with the Society, to proceed on her voyage provided that, in their opinion, she is in a fit and efficient condition. Such certificates will embody the Surveyors' recommendations for continuance of class, and in all cases are subject to confirmation by the Committee.

14. Withdrawal of Class. (*a*) *Owner's request.*—When the class of a ship, for which the Rules as regards surveys on hull and machinery have been complied with, is withdrawn from the Register Book by the Committee in consequence of a request from the Owner, this will be indicated by the insertion of three dots (...) in the Register Book, under which the date of such withdrawal will be recorded.

(*b*) *Non-Compliance with the Rules.*—When the Rules as regards surveys on the hull or machinery have not been complied with, and the ship thereby is not entitled to retain her class in the Register Book, the class will be expunged with a red line, under which the date of such deletion will be recorded.

(*c*) *Reported Defects.*—When it is found from reported defects in the hull or machinery that a ship is not entitled to retain her class in the Register Book, and the Owner fails to repair such defects in accordance with the Society's requirements, the class will be expunged with a black line, under which the date of such deletion will be recorded.

(*d*) *Infringement of Freeboard Conditions.*—Where any ship proceeds to sea with a less freeboard than that approved by the Committee or where the freeboard mark is placed higher on the ship's sides than the position assigned or approved by the Committee, the ship's class will be liable to be expunged from the Register Book.

15. Reclassification of Ships.—When reclassification is desired for a ship for which a character of classification in the Register Book previously assigned has been withdrawn, or deleted, application is to be made to the Committee in writing.

The Committee will in such cases direct a special survey of hull and machinery, appropriate to the age of the ship and circumstances of the case, to be carried out by the Society's Surveyors.

If at such survey the ship be found or placed in a good and efficient condition in accordance with the requirements of the Rules and to the satisfaction of the Surveyors, the Committee will be prepared to reinstate her original character of classification in the Register Book or assign such other character as may be deemed necessary.

The date of reclassification will be recorded in the Register Book and the subsequent Special Surveys of hull and machinery, required by the Rules for maintenance of class, will date therefrom.

4th November, 1948.

PERIODICAL SURVEY REQUIREMENTS.

Section 1.

ANNUAL OR OCCASIONAL SURVEYS.

1. Annual Surveys should, if practicable, be held concurrently with freeboard surveys. All ships are to be examined in dry dock at intervals of approximately one year.

2. The Surveyors are to examine the ship externally and, as necessary, internally, in order to satisfy themselves generally as to her condition. Special attention is to be given to parts of the structure particularly liable to excessive deterioration from causes such as chafing, lying on the ground, or handling of cargo.

3. In particular the following parts are to be examined :—

Hatchways with their closing and securing appliances, ventilators and other deck openings. Casings and superstructure bulkheads with their closing appliances. Windlass and equipment. Cargo and coaling doors, ash shoots and other openings in the shell plating. Rudder, main and auxiliary steering gear.

4. Special attention is to be paid to the examination of all parts of rod and chain steering gears. All pins are to be examined and the chain in the vicinity of the blocks is to be cleaned and examined for wear and tear. Any length of chain so worn that its mean diameter at its most worn part is reduced to the size given in the following Table is to be renewed.

Original Diameter of Chain.	Mean Diameter requiring Renewal of Chain.	Original Diameter of Chain.	Mean Diameter requiring Renewal of Chain.	Original Diameter of Chain.	Mean Diameter requiring Renewal of Chain.
Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
$\frac{3}{8}$	$\frac{5}{16}$	$\frac{13}{16}$	$\frac{23}{32}$	$1\frac{1}{4}$	$1\frac{1}{8}$
$\frac{7}{16}$	$\frac{3}{8}$	$\frac{7}{8}$	$\frac{25}{32}$	$1\frac{5}{16}$	$1\frac{3}{16}$
$\frac{1}{2}$	$\frac{7}{16}$	$\frac{15}{16}$	$\frac{27}{32}$	$1\frac{3}{8}$	$1\frac{1}{4}$
$\frac{9}{16}$	$\frac{1}{2}$	1	$\frac{29}{32}$	$1\frac{7}{16}$	$1\frac{5}{16}$
$\frac{5}{8}$	$\frac{9}{16}$	$1\frac{1}{16}$	$\frac{15}{16}$	$1\frac{1}{2}$	$1\frac{3}{8}$
$\frac{11}{16}$	$\frac{5}{8}$	$1\frac{1}{8}$	1	$1\frac{9}{16}$	$1\frac{7}{16}$
$\frac{3}{4}$	$\frac{21}{32}$	$1\frac{3}{16}$	$1\frac{1}{16}$	$1\frac{5}{8}$	$1\frac{15}{32}$

The various parts of the auxiliary steering gear are to be examined in order to ascertain that the gear is in good and workable condition.

All replacements of chains are to be subjected, under the Society's supervision, to the proof tests as set forth for short link cables in Section 14 of the Rules for Quality and Testing of Materials and the certificates are to be produced.

It is recommended that the breaking test as required in Section 14 mentioned above should also be applied to these chains, and that the tests be made at a proving establishment recognised by the Committee.

It is recommended that repaired chains be tested by the repairers and a certificate to that effect be produced.

It is recommended that a set of spares as required by Section 27, clause 3(*d*) of the Rules be provided.

5. When the cement in the bottom is removed, opportunity is to be given to examine the condition of the bottom plating before new cement is laid.

If the engines or boilers are removed at any time, the structure under them is to be surveyed.

The masts and spars are to be examined by the Surveyors when deemed necessary on occasions other than Special Surveys.

6. The requirements for the survey of main and auxiliary engines, boilers and electrical equipment, are set forth in Section 4, Periodical Survey Requirements.

When a ship is in dry dock, the propeller, after end of stern bush, and outside fastenings of all sea connections to main and auxiliary machinery and boilers are to be examined.

The amount of wear down in the stern bush is to be noted.

Section 2.

PERIODICAL SURVEYS—HULL. (*See Section 3 for Petroleum Tankers.*)

(A) GENERAL REQUIREMENTS (*see also* B, C *and* D).

1. The ship is to be placed on blocks of sufficient height in a dry dock, or on a slipway; proper stages are to be made, and the holds and peaks are to be cleared for examination.

2. In ships having a single bottom the limber boards and ceiling equal to not less than two strakes fore and aft on each side are to be removed, one such strake being taken from the bilges. Where the ceiling is fitted in hatches, the whole of the hatches and one strake of ceiling at the bilges are to be removed.

3. If the ship has a double bottom a sufficient amount of ceiling is to be removed to enable the condition of the inner bottom to be ascertained, and if it is found that the plating is free from dirt and rust, the removal of the remainder of the ceiling may be dispensed with. The bilges and limbers all fore and aft are to be cleaned out, so as to allow of these parts being properly examined.

4. The coal bunkers of steam ships are to be cleared for examination, and ceiling is to be removed as in the holds.

5. The steel work is to be exposed for examination and cleaned. Special attention is to be given to the examination of the ash shoots, and the shell plating in way of the openings.

If the Surveyor deems it necessary he may require holes to be drilled in any portion of the structure where signs of wastage are evident, to ascertain the thickness of the material. Any parts of the structure which are found defective or materially reduced in scantlings are to be made good by materials equal in scantlings and quality to those approved in the original construction of the ship.

Where considered necessary by the Surveyor, the surfaces are to be recoated.

6. In cases in which the inner surface of the bottom plating is covered with cement or asphalt, the removal of this covering may be dispensed with; provided it be carefully inspected, tested by beating or chipping, and found sound and adhering satisfactorily to the steel.

7. The double bottom tanks are to be tested by a head of water to the light water-line, but in no case less than 8 feet above the inner bottom. Double bottom compartments, which are used for the carriage of oil fuel, are to be tested by a head of water extending to the load water-line, or by a head sufficient to give the maximum pressure which can come upon them in practice, whichever is the greater.

Where peak tanks or deep tanks for carrying water ballast are fitted, their watertightness is to be tested by a head of water not less than 8 feet above the crown of the tank.

All water ballast tanks are to be cleaned out to admit of their being properly examined inside, special attention being given to the tanks under the boiler spaces.

Deep tanks constructed for carrying oil but not used solely for this purpose, also peak tanks used for carrying oil fuel, are in each case to be examined internally and are to be tested by a head sufficient to give the maximum pressure which can be experienced in practice or 8 feet, whichever is the greater.

In the case of motor and other ships burning oil fuel and carrying it in the double bottom and in oil fuel bunkers, these compartments need not be examined internally provided upon a general external examination the Surveyor finds their condition to be satisfactory. In these cases the tanks are to be tested by a head as stated above.

8. When a wood deck originally required to be 3 inches thick is worn to $2\frac{1}{2}$ inches, or $2\frac{1}{2}$ inches to 2 inches, it is to be renewed. If, however, such deck is found on survey to be in good condition the case will, upon application, receive the consideration of the Committee.

9. The masts, spars, rigging, anchors and general equipment are to be examined and either found, or placed in good and efficient condition.

10. The hatch covers and supports throughout are to be examined in position at the hatchways, and, if defective, are to be renewed or made good.

The Surveyor should satisfy himself as to the efficiency of the tarpaulins, cleats, battens and other means of securing the hatches.

The ventilator coamings and covers are to be examined, and special care is to be taken to see that they are in an efficient condition.

11. The rudder, quadrant, tiller, steering gear, engine and its connections and control gear are to be examined.

Special attention is to be paid to the examination of all parts of rod and chain gears. All pins are to be examined and the chain is to be cleaned and examined for wear and tear. Any length of chain so worn that its mean diameter at its most worn part is reduced to the size as given in the Table in **Section 1** of these Regulations is to be renewed.

The various parts of the auxiliary steering gear are to be assembled and examined to ascertain that the gear is in good and workable condition.

All replacements of chains are to be subjected, under the Society's supervision, to the proof tests as set forth for short link cables in **Section 14** of the **Rules for Quality and Testing of Materials**, and the certificates are to be produced. It is recommended that, in addition, the breaking test as required in **Section 14** mentioned above should also be applied to these chains, and that the tests be made at a proving establishment recognised by the Committee.

It is recommended that repaired chains be tested by the repairers and a certificate to that effect be produced.

It is recommended that a set of spares as required by Section 27, clause 3(*d*) of the Rules be provided.

12. The windlass, pumps, sluice valves, watertight doors, and air and sounding pipes are to be carefully examined.

The Surveyor is to see that striking plates are fitted under all sounding pipes.

13. Where holds are insulated for the purpose of carrying refrigerated cargoes, and the ship in way of the insulation was examined by the Society's Surveyors at the time such insulation was fitted, it will be sufficient to remove the limbers and hatches to enable the plating to be examined.

14. The freeboard recorded in the Register Book is to be verified.

15. The main and auxiliary engines and boilers and electrical equipment are to be examined and favourably reported on by the Society's Engineer Surveyors.

For Periodical Special Surveys of main and auxiliary engines and boilers and electrical equipment *see* Section 4, Periodical Survey Requirements.

(B) AT EACH PERIODICAL SPECIAL SURVEY AFTER THE FIRST.

THE FULL REQUIREMENTS OF (A) TOGETHER WITH THE FOLLOWING :—

1. An additional amount of ceiling in the holds and in coal bunkers is to be removed to enable the condition of the inner bottom plating, stanchion feet, and the bottom plating of bulkheads and tunnel sides to be examined. If the Surveyor deems it necessary, the whole of the ceiling is to be removed.

2. In ships having a single bottom the limber boards and ceiling equal to not less than three strakes fore and aft on each side are to be removed, one such strake being taken from the bilges. Where the ceiling is fitted in hatches, the whole of the hatches and one strake of ceiling in the bilges are to be removed.

3. All double bottom and other tanks, including oil fuel bunkers are to be cleaned out, to admit of their being properly examined inside.

4. The plating in way of the sidelights is to be examined.

5. The chain cables are to be ranged for inspection, and the anchors and chains examined and placed in good working condition. If any length of chain cable is found to be reduced in mean diameter at its most worn part to the extent indicated in Table 55, it is to be renewed.

6. The chain locker is to be examined internally.

(C) AT EACH PERIODICAL SPECIAL SURVEY WHEN THE SHIP IS 10 YEARS OLD AND OVER.

THE FULL REQUIREMENTS OF (A) AND (B), TOGETHER WITH THE FOLLOWING :—

1. The steel work is to be cleaned and the rust removed.

2. Casings of pipes, spar ceiling and lining in way of the sidelights are to be removed as required by the Surveyor.

3. The whole of the ceiling in the bunkers is to be removed. If it is found, after removal of portions of the ceiling in the holds, that the steel work is in good condition, free from rust, and coated, the removal of the whole may be dispensed with.

4. The inside of coal bunkers and the parts in way of the boilers are to receive the Surveyors' particular attention.

5. The cement chocks at the ship's sides are to be examined, and portions removed, so that the condition of the adjacent steel work can be ascertained.

6. Where the holds are insulated for the purpose of carrying refrigerated cargoes, and the ship in way of the insulation was examined by the Society's Surveyors at the time such insulation was fitted, the limbers and hatches are to be lifted, and enough insulation is to be removed in each of the chambers to admit of the framing and plating being exposed to satisfy the Surveyor of their general condition.

7. All mast and bowsprit wedging is to be removed. If the plating is doubled in way of the wedging, the latter need be removed only at the first Periodical Special Survey after the ship is 10 years old. At this same Survey the standing rigging of sailing ships is to be lifted, and the service and parcelling stripped off the nips, bends and splices for examination; if, however, the rigging has been recently fitted, particulars of the cases are to be submitted for the consideration of the Committee. The bobstay pins, the deadeyes and rigging screws to the whole of the standing rigging, also all bolts or pins and fittings are to be carefully examined.

(D) AT THE FIRST PERIODICAL SPECIAL SURVEY HELD AFTER THE SHIP IS 24 YEARS OLD ADD AT EVERY 12 YEARS THEREAFTER OR AT THE NEXT PERIODICAL SPECIAL SURVEY AFTER THE EXPIRATION OF THE LATTER PERIOD.

THE FULL REQUIREMENTS OF (**A**), (**B**) AND (**C**), TOGETHER WITH THE FOLLOWING :—

1. The shell plating is to be drilled at such parts as the Surveyors may consider necessary to satisfy themselves as to the thickness. The number of holes drilled on each side of the ship is to be in no case less than three in each strake of plating not covered with cement, the holes being drilled about amidships, and in the vicinity of the peak bulkheads. All paint as well as rust is to be entirely removed before the plates are gauged, and the actual thicknesses at all parts drilled are to be detailed in the Surveyors' report.

The plating in way of cement in the bottom need not be drilled, provided the cement is found to be adhering satisfactorily to the plating, and the Surveyors consider drilling at this part unnecessary.

2. Where the holds are insulated for the purpose of carrying refrigerated cargoes, and the ship in way of the insulation was examined by the Society's Surveyors at the time such insulation was fitted, the limbers and hatches are to be lifted, and additional insulation is to be removed in each of the chambers to admit of the framing and plating being exposed to satisfy the Surveyor of the general condition of the same, and to enable the shell plating to be drilled as required by the Regulations.

3. All mast and bowsprit wedging is to be removed whether the plating in way is doubled or not.

4. In sailing ships the requirements of (**C**), clause 7, are to be complied with.

Section 3.

PERIODICAL SURVEYS—PETROLEUM TANKERS.

1. **Preparation of Tanks.**—(*a*) At all special surveys the tanks are to be cleaned out and thoroughly cleared of gas. Every precaution is to be taken to ensure safety during inspection.

(*b*) The strums of the cargo suction pipes are to be removed to facilitate examination of the shell plating and bulkheads in that vicinity.

2. **Testing.**—(*a*) Each oil compartment and cofferdam is to be tested by being filled with water to the top of the hatchway in the expansion trunk or cofferdam.

(*b*) The tanks may be filled to the light load line when the ship is in dry dock, and the remainder of the testing carried out afloat. The centre line bulkhead need not be tested independently.

(*c*) Where extensive repairs have been effected to the shell plating, the tanks should be tested by being filled when the vessel is in dry dock. If that is not practicable, particulars of the method proposed to be adopted in testing the tanks are to be submitted for approval.

(*d*) Where desired by the Owner, a system of examination and testing of the oil compartments may be adopted such that all compartments are examined and tested every four years, and that the period which elapses between consecutive examinations and testing of each compartment shall not exceed four years.

In such cases the certificate of classification will be endorsed "Progressive Survey of Oil Tanks" and this notation will also be printed in the Register Book.

The date of survey recorded in the Register Book will be the date on which the principal part of the requirements for Periodical Special Surveys is complied with.

Section 4.

PERIODICAL SURVEYS—MACHINERY.

ENGINES AND BOILERS OF STEAM SHIPS.

1. **The machinery and boilers of all steam ships are to be surveyed annually if practicable, and in addition are to be submitted to a Special Survey upon the occasions of the ships undergoing the Periodical Special Surveys, prescribed in the Rules, unless the machinery and boilers have been specially surveyed within a period of twelve months.**

2. At these Special Surveys, and on other occasions if deemed necessary by the Surveyors, the propeller, stern-bush, sea connections, and their fastenings, are to be examined while the ship is in dry dock.

3. **The screw shaft is to be drawn at intervals of not more than three years in the cases of shafts fitted with continuous liners, and of shafts fitted with approved glands, or other approved appliances, at their after ends to permit of them being efficiently lubricated. In the cases of other screw shafts, they should be drawn at intervals of not more than two years. (On the application of Owners, the Committee will be prepared to give consideration to the circumstances of any special case.)**

4. (*a*) The cylinders, pistons, slide valves and crank shafts of reciprocating engines, and the blading, rotor shafts, and rotors as far as practicable, of turbine engines, together with thrust and intermediate shafts, pumps and condensers, are to be examined, and if necessary the condenser is to be tested. Where reduction gears are fitted, the shafts, shaft bearings, and teeth of the gears are to be examined.

(*b*) Where exhaust steam turbines are connected to the main shafting of steam reciprocating engines, through reduction gearing and hydraulic clutches or other mechanical means, or electric motors, the turbines, gearing and clutches of electric motors are to be examined as far as practicable. If found to be satisfactory, they need not be dismantled.

Where the power of the turbine is transmitted through a hollow gear wheel shaft attached to the main shafting by means of a coned coupling the coned end of the internal driving shaft is to be exposed and the shaft to be examined as far as practicable.

These requirements will also apply to exhaust steam turbines, and other appliances driven by them, which are used in conjunction with the main engines.

5. The valves, cocks, pipes and strainers of the pumping arrangements are to be examined, items being opened up as deemed necessary by the Surveyor. In particular, the valves, cocks and strainers of the bilge system, including the bilge injection, are to be opened up for internal examination and tested under working conditions.

6. The boilers, superheaters and economisers are to be examined internally and externally, and if deemed necessary by the Surveyors, the pressure parts are to be drilled or tested by hydraulic pressure; the safe working pressure is to be determined by their actual condition.

7. The principal mountings on boilers, superheaters and economisers are to be opened up and examined and the safety valves set under steam to pressures not greater than 3 per cent. above the approved working pressures of the respective parts.

The remaining mountings are to be examined externally and are to be opened up for internal examination if deemed necessary by the Surveyor.

8. At each Periodical Special Survey after the first, a selected number of main steam pipes, also of auxiliary steam pipes over 3 inches bore, made of iron, steel, or solid drawn copper, supplying steam for essential services at sea, are to be removed for examination and tested by hydraulic pressure to double the working pressure.

Alternatively, all steam pipes as described above are to be tested in place to double the working pressure. In either case, sufficient lagging is to be removed at the discretion of the Surveyor to facilitate examination and hammer testing.

Copper steam pipes as described above, but having a brazed longitudinal joint, are to be entirely stripped and tested to double the working pressure at each Special Survey.

9. At each Periodical Special Survey the oil fuel pumps for oil fired main, auxiliary and donkey boilers are to be opened up for examination. A general examination is to be made of all valves, tanks, pipes and deck control gear in connection with the oil fuel and steam smothering installations, and the installations are to be tested under working conditions.

10. At all Boiler Surveys the oil fuel and steam smothering installations are to be tested under working conditions and a general examination made of the fuel tank valves, deck control gear and oil discharge pipes between the pumps and furnaces.

11. The electrical equipment is to be examined.

12. If satisfactory, these Surveys will be recorded in the Register Book thus:—"LMC3,49" *in red* or "B&MS3,49" *in red.*

13. "LMC" (LLOYD'S MACHINERY CERTIFICATE) denotes that the machinery and boilers are fitted in accordance with the Rules; and when followed by a date, indicates that they were found at that time to be in good condition. "MS" with a date denotes that the engines at that time were found upon inspection to be in good condition. "BS" with a date denotes that the boilers were found upon inspection at that time to be in good condition.

14. "B&MS" (BOILERS AND MACHINERY SURVEYED), with a date, denotes that the boilers and machinery, though not fitted strictly in accordance with the Rules, were found upon inspection at that time to be in good condition.

15. In the event of either the machinery or boilers appearing to be impaired to such an extent as to render it desirable that either or both be specially surveyed within the periods prescribed above, a Certificate for either machinery or boilers for a limited period will be granted according to the nature of the case.

BOILERS (INCLUDING PRESS BOILERS).

1. Water tube boilers and their superheaters and economisers are to be specially surveyed annually.

2. The boilers, superheaters and economisers of all ships, including sailing ships, are to be specially surveyed when four years old, also when six years old, and subsequently they are to be specially surveyed annually.

3. Domestic boilers intended for working pressures exceeding 50 lb. per square inch or having heating surfaces greater than 50 square feet, also press boilers and similar apparatus in floating whale-oil factories are to be specially surveyed when four and six years old, and subsequently they are to be specially surveyed annually.

4. At these surveys the boilers, superheaters and economisers are to be examined internally and externally, and if deemed necessary by the Surveyors, the pressure parts are to be drilled or tested by hydraulic pressure; the safe working pressure is to be determined by their actual condition.

5. The principal mountings on boilers, superheaters and economisers are to be opened up and examined, and the safety valves set under steam to pressures not greater than 3 per cent. above the approved working pressures of the respective parts. The remaining mountings are to be examined externally and are to be opened up for internal examination if deemed necessary by the Surveyor.

6. At each Periodical Special Survey the oil fuel pumps for oil fired main, auxiliary and donkey boilers are to be opened up for examination. A general examination is to be made of all valves, tanks, pipes and deck control gear in connection with the oil fuel and steam smothering installations, and the installations are to be tested under working conditions.

7. At all Boiler Surveys the oil fuel and steam smothering installations are to be tested under working conditions and a general examination made of the fuel tank valves, deck control gear and oil discharge pipes between the pumps and furnaces.

8. If satisfactory these Surveys will be recorded in the Register Book thus:—"BS3,49" *in red,* "DBS3,49" *in red,* and "Pr.BS3,49" *in red* respectively.

9. "BS" (BOILERS SURVEYED) or "DBS" (DONKEY BOILER SURVEYED), or "Pr.BS" (PRESS BOILERS SURVEYED) with a date, denotes that the boilers were found upon inspection at that time to be in good condition.

10. In the event of the boilers, superheaters or economisers appearing to be impaired to such an extent as to render it desirable that they be specially surveyed within the periods prescribed above, a Certificate for a limited period will be granted according to the nature of the case.

PETROL, PARAFFIN, AND HEAVY OIL ENGINES AND THEIR AUXILIARIES.

1. (*a*) In the cases of ships propelled by petrol, paraffin, and heavy oil engines a complete survey of the machinery, as detailed in clause 2, is to be held upon the occasions of the ships undergoing the Periodical Special Surveys prescribed in the Rules, unless the machinery has been thus surveyed within a period of twelve months.

(*b*) At each intervening period of two years a Modified Survey of the machinery, as detailed in clause 3, is to be held.

2. Complete Periodical Survey.—The Complete Periodical Survey required in clause 1, paragraph (*a*), will consist of the following :—

(*a*) The main engines and their auxiliaries are to be examined throughout, viz., all cylinders, pistons, valves and valve gears, connecting rods and their top and bottom end brasses, crossheads, guides, pumps, clutches, reversing gears, crank, thrust and intermediate shafts, propeller, stern bush, sea connections and their fastenings.

(*b*) If compressed air is employed, the cylinders, pistons and valves of the compressors are to be examined. The air receivers are to be examined internally if possible, and, together with the air pressure pipes, are to be cleaned internally, if necessary, by means of steam, or otherwise. If the air receivers cannot be examined internally, they are to be tested by hydraulic pressure to twice the working pressure, attention being specially given in the case of welded receivers to the end and longitudinal joints.

(*c*) If electric ignition is employed the electric leads are to be examined and the system is to be tested. The magnetos are to be sent for inspection and overhaul to competent repairers.

(*d*) Where reduction gears are fitted, the shafts, shaft bearings and teeth of the gears are to be examined.

(*e*) Separate fuel storage tanks and daily service tanks, their fittings and connections are to be examined and, if deemed necessary by the Surveyor, the tanks are to be tested to the same pressure as specified for new tanks.

(*f*) The valves, cocks, pipes and strainers of the pumping arrangements are to be examined, items being opened up as deemed necessary by the Surveyor. In particular, the valves, cocks and strainers of the bilge system, including the bilge injection, are to be opened up for internal examination and tested under working conditions.

(*g*) In cases where steam is used for essential services at sea, the condenser, air, circulating, and feed pumps are to be examined and the steam pipes examined and tested in accordance with the Rules for the Periodical Surveys of Engines and Boilers of Steam Ships.

(*h*) The electrical equipment is to be examined.

(*i*) The manœuvring of the engines is to be tested under working conditions.

3. **Modified Survey.**—The Modified Survey required in clause 1, paragraph (*b*), will consist of the following, viz. :—

(*a*) The parts of the engines which the engineers of the ship open up for adjustment and overhaul should be examined and reported upon. The survey is to include, for each main engine, the examination of at least two pistons, with their cylinders, covers and valves, connecting rods and their top and bottom end brasses, two of the main crank shaft journals and bearings, and one of the intermediate shaft bearings. If these are all satisfactory, their condition may be taken as representing that of the other similar parts.

In the case of main engines having less than four cylinders, one of each of the parts aforementioned will be considered sufficient if found satisfactory.

Where petrol, paraffin, and heavy oil engines are fitted for driving auxiliary machinery, a similar course is to be adopted, but in this case one of each of the parts aforementioned of each engine will be sufficient, if found to be satisfactory.

(*b*) The valve gears are to be examined, as far as practicable. If found to be satisfactory, they need not be dismantled.

(*c*) The pumps, air compressors and clutches (where fitted), and reversing gears, are to be examined as far as practicable. If found to be satisfactory, they need not be dismantled.

(*d*) If compressed air is employed, the air receivers are to be examined internally if possible, and, together with the air pressure pipes, are to be cleaned internally, if necessary, by means of steam, or otherwise.

(*e*) If electric ignition is employed the electric leads are to be examined and the system is to be tested. The magnetos are to be sent for inspection and overhaul to competent repairers.

(*f*) Separate fuel storage tanks and daily service tanks, their fittings and connections, are to be examined externally, and, if deemed necessary by the Surveyor, the tanks are to be tested to the same pressure as specified for new tanks.

(*g*) If the examination reveals any defects, the Surveyor should recommend such further opening up as he may consider to be necessary.

4. **Screw Shaft.**—The screw shaft is to be drawn at intervals of not more than three years in the cases of shafts fitted with continuous liners, and of shafts fitted with approved glands, or other approved appliances, at their after ends to permit of them being efficiently lubricated. In the cases of other screw shafts, they should be drawn at intervals of not more than two years. (On the application of owners, the Committee will be prepared to give consideration to the circumstances of any special case.)

5. **Record of Survey.**—If the various parts mentioned in clauses 2 or 3 are found to be in a satisfactory condition, and the Surveyor finds that the machinery generally is in good order, he should recommend the ship to have a fresh record of LMC, or LMC(M) as the case may be.

In the event of either the main or auxiliary machinery appearing to be impaired to such an extent as to render it desirable that either or both be specially surveyed within the periods prescribed above, a certificate for a limited period will be granted according to the nature of the case.

6. **Continuous Surveys.**—In the case of motorships fitted with heavy oil engines, if arrangements be made to open up the various parts of the machinery in regular rotation from time to time, so that the Society's Surveyors may examine the whole of the machinery every four years, the Rule requirements, both for Modified and Complete Periodical Surveys, will be complied with if such a procedure be adopted.

When the full requirements of the Complete Periodical Survey have been complied with a record of LMC (CS) (with date), (Lloyd's Machinery Certificate, Continuous Survey) will be assigned in the Register Book, the date being that of the completion of a cycle of the Continuous Survey.

ELECTRICAL EQUIPMENT.

1. On the occasions of the ships undergoing the Periodical Special Surveys prescribed in the Rules, the electrical equipment is to be examined.

2. (*a*) Where the electrical equipment is for lighting purposes only, the installations are to be generally examined and tested under working conditions.

(*b*) The fittings on all main and sub-distribution switchboards and boxes are to be examined to ensure that the circuits are not overfused.

(*c*) The electric cables are to be examined as far as practicable without dismantling any fixtures or casings unless such dismantling is deemed to be necessary as the result of tests and observation.

(*d*) A test is to be made on generators, cables, heaters, fittings, etc., and the insulation resistance is to be not less than 100,000 ohms.

3. (*a*) Where the electric generators are also used for supplying power for driving auxiliary machinery, steering gear, windlass or refrigerating machinery, the prime movers are to be opened out for examination in accordance with the Rules for the survey of machinery.

(*b*) The generators and all motors driving essential auxiliary machinery are to be examined as far as practicable.

(*c*) All fittings on main and sub-distribution switchboards and boxes are to be examined to ensure that the circuits are not overfused.

(*d*) The electric cables are to be examined as far as practicable without dismantling any fixtures or casings unless such dismantling is deemed to be necessary as the result of tests and observation.

(*e*) A test is to be made on generators, motors, cables and other apparatus, heaters, fittings, etc., and the insulation resistance is to be not less than 100,000 ohms.

(*f*) All generators are to be run in turn or simultaneously; all main switches and current breakers are to be operated, and all lamps, heaters, motors and other appliances run, though not necessarily under full load or simultaneously.

Section 5.

CLASSIFICATION OF SHIPS NOT BUILT UNDER SURVEY.

1. **Hull.**—When classification is desired for a ship not built under the supervision of the Society's Surveyors, application should be made to the Committee in writing.

Plans showing the main scantlings and arrangements are to be submitted for approval. These should comprise Midship Section, Longitudinal Section and Decks, and such other plans as may be requested. If plans cannot be obtained or prepared by Owners, facilities are to be given for the Society's Surveyors to take the necessary information from the ship.

Particulars of the process of manufacture and testing of the material of construction should be furnished.

The full requirements of the Periodical Special Survey (**C**) are to be complied with, except in a ship 20 years old or over, in which case Periodical Special Survey (**D**) is to be carried out. During the survey the Surveyors will satisfy themselves regarding the workmanship and verify the approved scantlings and arrangements. For this purpose, and in order to ascertain the amount of any deterioration, parts of the structure will require to be drilled as necessary. Full particulars of the anchors, chain cables and equipment are to be submitted.

Ships of recent construction will receive special consideration.

When the full survey requirements indicated above cannot be completed at one time, the Committee will consider granting an Interim Record with conditions regarding the completion of the survey. These conditions will depend on the merits of each particular case, which should be submitted for consideration.

2. **Machinery.**—To facilitate the survey, plans of the following items, together with the particulars of the materials of important forgings, also of those used in the construction of the boilers and air receivers, should be furnished :—

Steamers.	Oil Engine Ships.
(*a*) Boilers, superheaters and economisers.	(*a*) Crank, thrust, intermediate and screw shafting.
(*b*) Arrangement and drainage of steam pipes.	(*b*) Clutch, reversing and reduction gear.
(*c*) Arrangement of boiler feed system.	(*c*) Air receivers.
(*d*) Crank, thrust, intermediate and screw shafting.	(*d*) Oil fuel pumping arrangements and oil fuel tanks not forming part of the structure of the ship.
(*e*) Reduction gear.	(*e*) Bilge and ballast pumping arrangements.
(*f*) Oil fuel pumping arrangements and oil fuel tanks not forming part of the structure of the ship.	(*f*) Boilers.
(*g*) Bilge and ballast pumping arrangements.	(*g*) Electrical circuits.
(*h*) Electrical circuits.	

The main and auxiliary machinery, also steam pipes, feed pipes, compressed air pipes and boilers are to be examined as required for Periodical Special Surveys, and their working pressures are to be determined from their actual scantlings in accordance with the Rules.

The screw shaft is to be drawn and examined.

The bilge, ballast and oil fuel pumping arrangements are to be examined and amended as necessary to comply with the Rules.

Oil burning installations are to be examined as required for Periodical Special Surveys and found, or amended, to comply with the requirements of the Rules; they are also to be tested under working conditions.

The electrical equipment is to be examined as required at Periodical Special Surveys.

The whole of the machinery is to be tried under working conditions to the Surveyors' satisfaction.

A First Entry Report is to be prepared by the Surveyors.

3. **Periodical Surveys.**—The Periodical Surveys are subsequently to be held as in the case of ships built under survey.

71, Fenchurch Street, London, E.C.3.

4th November, 1948.

BUILDING OF

STEEL VESSELS.

INDEX

CONSTRUCTION OF STEEL SHIPS

A

	Section.	Clause.	Page.
Access Hatchways	23	6	55
After Peak, bulkhead	16	1	46
„ „ framing	6	1	39
„ „ panting arrangements ...	7	4	40
Air Pipes	24	—	55
Anchors, number and weight	33	3	63
„ design	33	3	63
„ testing	33	5	63
„ working arrangements ...	33	6	63
Asphalt, for protection of steelwork ...	30	1	61

B

	Section.	Clause.	Page.
Bar Keel	3	3	34
Battens, cargo	29	2	60
„ hatchway, ...	23	5	55
Beam Knees	14	3	45
Beams	14	—	44
„ at deep tanks...	19	2	49
„ at watertight flats	16	7	48
„ hatchway	23	3	54
„ in peaks	9	2	41
„ strong hatch end	15	5	46
Boats	33	7	64
Boiler bearers	22	2	53
„ room, framing	6	6	39
Bottom Forward, strengthening ...	7	—	40
„ plating, welded seams	7	4	40
Bracket Floors	5	5	37
„ „ frames and reversed frame ...	5	5	37
Brackets, tank side	5	9	38
„ deck longitudinals	14	3	45
„ bulkhead stiffeners	16	5	47
Breadth definition	2	2	34
Bridge, long	12	2	43
„ short	12	1	43
Bulkheads at ends of raised quarter deck	13	2	44
„ „ superstructure ...	12	4	43
„ centre line, oil fuel tanks ...	20	7	51
„ deep tanks	19	1	49
„ oil fuel tanks	20	2	50
„ **Non-Watertight**	18	—	49
„ „ centre line ...	18	1	49
„ „ coal bunker ...	18	2	49
Bulkheads, Watertight, ...	16	—	46
„ „ boundary connections ...	16	6	48
„ „ doors	16	12	48
„ „ height	16	2	47
„ „ longitudinal ...	16	8	48
„ „ number ...	16	1	46
„ „ omission ...	16	1	46
„ „ peaks	16	1	46
„ „ plating ...	16	3	47
„ „ recesses and flats	16	7	48
„ „ stiffeners ...	16	4	47
„ „ „ welded	16	11	48
„ „ tugs	34	5	64
Bulwarks	25	1	56
Bunker bulkheads	18	2	49
„ hatchways	23	6	55
„ scuttles	23	7	55
Butts of shell plating	7	3	40

C

	Section.	Clause.	Page.
Cables—*see* **Chain Cables**			
Cargo Battens	29	2	60
Carriers, hatchway beam	23	3	54
Casings, protecting machinery spaces, exposed	22	6	53
„ protecting machinery spaces, protected	22	7	53
Caulking	32	5	62
„ decks	11	8	43
„ double bottom	5	15	38
„ watertight bulkheads	16	13	48
Ceiling	20	1	50
„ omission	5	7	38
„ over oil fuel tanks	20	12	51
„ refrigerated holds	29	1	60
„ ships discharged by grabs ...	5	7	38
Cement Wash	30	2	61
Cementing	30	1	61
Centre girder in double bottom ...	5	2	36
Centre Keelson	4	3	35
Centre line Bulkheads. non-watertight	18	1	49
„ „ „ oil fuel tanks ...	20	7	51

INDEX.

	Section.	Clause.	Page.
Chain Cables	33	4	63
„ „ special steel	33	4	63
„ „ testing	33	5	63
„ „ working arrangements ...	33	6	63
Chain Locker	33	6	63
„ „ abaft collision bulkhead ...	16	9	48
Chains, steering...	27	3	59
Cleats, hatchway	23	5	55
Coal Bunker, bulkheads	18	2	49
„ „ framing	6	6	39
Coamings, hatchway	23	1	53
„ ventilator	24	2	55
Cofferdams	20	12	51
Collision Bulkhead, height	16	2	47
„ „ position	16	1	46
Companionways	23	9	55
Compositions, deck	11	7	43
Concentration of loading	11	4	43
Continuity of Strength	11	5	43
Countersinking	31	3	61
Coupling, rudder	26	6	58
Covers, hatchway	23	4	54
„ ventilator	24	3	56
Cruiser stern	6	5	39

D

Davits	33	7	64
Deadlights	25	7	57
Deck, compositions	11	7	43
„ transverses	15	6	46
Decks	11	—	42
„ caulking	11	8	43
„ doubling at openings	11	5	43
„ protection under donkey boiler ...	22	5	53
„ wood	11	6	43
Deckhouses	12	5	44
Deep Tanks	19	—	49
„ „ beams	19	2	49
„ „ boundary angles	19	1	49
„ „ bulkheads	19	1	49
„ „ carrying oil as cargo ...	21	—	52
„ „ „ „ fuel for ship's use	20	—	50
„ „ deck plating over	20	2	50
„ „ side frames	19	3	50
„ „ testing	19	8	50
„ „ tunnels in	17	6	49
„ „ washplates	19	5	50
Definitions	2	—	34
Depth, definition	2	3	34
	2	5	34
Derrick Posts	28	1	59
Detached Superstructures	12	—	43
Diaphragm plates at raised quarter deck	13	3	44
Discharges, sanitary	25	4	57
Doors, watertight	16	12	48
Double Bottom	5	—	36
„ „ bottom forward ...	8	3	40
„ „ machinery space ...	5	10	38
„ „ tanks carrying oil fuel for ship's use	20	—	50
„ „ under pillars	15	7	46
Drainage, double bottom	5	14	38
„ single bottom...	4	8	36
Draught, definition	2	4	34
Drip trays	20	12	51

E

Effective Superstructure	2	6	34
Engine casing, exposed	22	6	53
„ „ protected	22	7	53
„ room skylights	22	8	53
„ seating	22	1	52
Equipment	33	—	62
„ numeral	33	2	62
„ tugs	34	9	64

F

Flanges of angles, breadth of	31	1	61
Flats, watertight...	16	7	48
Floor, bottom forward	8	3	40
„ bracket	5	5	37
„ in engine space	22	1	52
„ „ machinery space, double bottom	5	10	38
„ „ „ single bottom	4	5	36
„ panting region aft	9	4	41
„ plate, double bottom	5	4	36
„ „ single „	4	1	35
„ tugs	34	3	64
„ watertight	5	4	36
Flush Bunker Scuttles	23	7	55
Forecastle	12	1	43
Frame Spacing	6	2	39

	Section.	Clause.	Page.
Framing	6	—	39
„ boiler room	6	6	39
„ coal bunkers	6	6	39
„ deep tank	19	3	50
„ „ „ carrying oil fuel ...	2	4	34
„ ice navigation	10	1	41
„ in machinery space	22	3	53
„ main	6	3	39
„ panting region	9	3	41
„ peak	6	1	39
„ superstructures	6	4	39
„ 'tween deck	6	4	39
Freeing Ports	25	2	56

G

Garboard Strake	7	1	40
Girder, centre	5	2	36
„ side, transverse framing	5	3	36
„ „ longitudinal „	5	6	37
Girders, deck	15	—	45
„ horizontal in oil fuel bunkers ...	20	3	50
„ under engine seating	22	1	52
Gratings, stokehold	22	8	53
Gudgeons	3	5	34
Gusset at margin plates	5	9	38

H

Hatch coamings, as girders	15	4	45
„ „ construction	23	2	54
„ „ height	23	1	53
„ covers	23	4	54
„ end beams	15	5	46
Hatchway **Beams**	23	3	54
„ „ carriers	23	3	54
Hatchways	13	—	44
„ access	23	6	55
„ battens	23	5	55
„ bunker	23	6	55
„ trimming	23	6	55
„ trunked	23	8	55
„ tugs	34	8	64
Hawse Pipes	33	6	63
Horizontal Girders in oil fuel bunkers ...	20	3	50

I

Ice Strengthening	10	—	41
Inner Bottom Plating	5	7	38
Intermediate frames, ice navigation ...	10	1	41

J

Joggling	3	3	62

K

	Section.	Clause.	Page
Keel, bar	3	3	34
„ material	3	1	34
„ plate	3	2	34
Keelsons, centre	4	3	35
„ in engine room	4	4	36
„ side	4	4	36
„ thickness in machinery space ...	4	5	36
„ tugs	34	4	64

L

Length, definition	2	1	34
Liners to shell plating	32	3	62
Lightening holes	5	7	38
Loading aground	4 5	7 12	36 38
„ certificate for oil cargo ...	21	3	52
„ concentration of	11	4	43
Longitudinal framing	5	6	37
„ „ bottom forward	8	3	40
„ watertight bulkheads ...	16	8	48
Longitudinals	14	—	44
Lower decks	11	1	42

M

Machinery casings, exposed	22	6	53
„ „ protected	22	7	53
„ „ tugs	34	6	64
„ spaces	22	—	52
„ „ additional strengthening	22	4	53
„ „ increase in double bottom scantlings ...	5	10	38
Manholes	5	8	38
Margin connections	5	9	38
„ plate	5	7	38
Masts	28	1	59
Material, distribution	1	6	33
„ rudder	26	1	58
„ side scuttles	25	7	57
„ valves and pipes	25	5	57
Mill scale, removal	30	3	61

N

Non-Watertight Bulkheads	18	—	49
Numeral, equipment	33	2	62
„ „ tugs	34	9	64

	Section.	Clause.	Page.
O			
Oil carried in deep tanks as cargo ...	21	—	52
„ fuel carried for ship's use	20	—	50
Oiltight work	32	6	62
Outriggers, mast...	28	3	60
P			
Painting	30	2	61
Panting arrangements	9	—	41
„ „ ice navigation ...	10	2	42
„ „ tugs	34	7	64
Peak tanks	19	—	49
„ „ carrying oil as cargo ...	21	—	52
„ „ testing	19	8	50
„ „ washplates	19	5	50
Pillars	15	—	45
„ in machinery space	22	3	53
Pintles, rudder	26	5	58
Pipes, material	25	5	57
„ protection...	25	6	57
Plans, submission	1	3	33
Plate floors	5	4	36
„ „ bottom forward	8	3	40
„ „ frames and reversed frames	5	4	36
„ „ longitudinal framing ...	5	6	37
„ keel...	3	2	34
Platform deck	11	1	42
Plating, tunnels...	17	2	48
„ watertight bulkheads	16	3	47
Poop	12	1	43
Propeller blades, ice navigation ...	10	9	42
Proportions	1	1	33
Q			
Quadrants	27	2	59
R			
Raised quarter deck	13	—	44
Recesses, watertight	16	7	48
Reversed frames, double bottoms ...	5	4	36
	5	5	37
„ „ single bottoms ...	4	2	35
Rigging	28	2	60
Riveting	31	—	61
„ bottom forward	8	5	40
Riveting, end attachments of bulkhead stiffeners	16	5	47
„ ice navigation	10	4	42
„ rudders	26	7	58
Rod and chain steering gear	27	3	59
Rudder	26	—	58
„ coupling	26	6	58
„ diameter	26	2	58
„ double plate	26	4	58
„ ice navigation	10	7	42
„ material	26	1	58
„ pintle	26	5	58
„ riveting	26	7	58
„ single plate	26	3	58
„ stops	27	6	59
S			
Sanitary Discharges	25	4	57
Screw Shaft, ice navigation	10	3	42
Scuppers	25	3	57
Scuttles, flush bunker	23	7	55
Sea Valves, ice navigation	10	10	42
Shaft Tunnels	17	—	48
Sheerstrake	7	1	40
„ opening for side scuttles ...	7	2	40
Shell Plating	7	—	40
„ „ bottom forward	8	2	40
„ „ ice navigation..... ...	10	3	42
„ „ in way of hawsepipes ...	33	6	63
„ „ openings for cargo doors, etc.	7	2	40
„ „ panting region	9	2	41
	9	3	41
Side girders in double bottom, bottom forward	8	3	40
„ „ longitudinal framing	5	6	37
„ „ transverse framing	5	3	36
„ keelsons	4	4	36
„ scuttles	25	7	37
Single bottoms	4	—	35
„ „ strengthening of bottom forward ...	8	4	40
Skylights, engine room	22	8	53
Sounding pipes	24	—	55
Springs to steering gear	27	4	59
Steering gear	27	1	59
Stem	3	4	34
„ ice navigation	10	6	42
Stern, Cruiser	6	5	39

	Section.	Clause.	Page.
Sternframe	3	5	34
Stiffeners, bunker bulkheads	18	2	49
„ non-watertight bulkheads ...	18	1	49
„ tunnel	17	2	48
„ watertight bulkheads ...	16	4	47
„ „ „ end attachment...	16	5	47
Stokehold gratings	22	8	53
Strength deck, definition	2	7	34
Strengthening of bottom forward ...	8	—	40
„ „ „ tugs ...	34	7	64
Stringer and tie plates	11	2	42
„ angles	11	3	43
„ ice navigation	10	5	42
Stringers, panting, abaft the collision bulkhead ...	9	3	41
„ „ forward of collision bulkhead ...	9	2	41
Strong beams in tugs	34	6	64
Superstructures, detached	12	—	43
„ end bulkheads ...	12	4	43
„ framing	6	4	39
„ strength at break ...	7	5	40
„ strengthening at ends	12	3	43

T

Tank side brackets	5	8	38
Tanks, deep (*see* **Deep Tanks**)	19	—	49
„ oil fuel	20	—	50
„ peak (*see* **Peak Tanks**)	19	—	49
Tarpaulins	23	5	55
Testing, decks	11	8	43
„ deep and peak tanks	19	8	50
„ oil fuel tanks	20	14	52
Tie plates	11	—	42
Tillers	27	1	59
Transverses, deck	15	6	46
Trimming hatchways	23	6	55
Trunked hatchways	23	8	55
Tugs	34	—	64
Tunnels, watertight	17	—	48
„ boundary angles ...	17	4	48
„ caulking and testing	17	9	49
„ in deep tanks ...	17	6	49
„ plating	17	2	48
'Tween deck framing	6	4	39

U

Uptakes, boiler	22	4	53

V

Valves, material	25	5	57
„ non-return	25	3	57
„ protection	25	4	57
Vegetable oil	25	6	57
Ventilators	21	2	52
„ coamings	24	—	55
„ covers	24	2	55
„ deep tanks	24	3	56
„ oil fuel tanks	19	6	50
„ tunnel	20	8	51
	17	8	49

W

Washplates, deep and peak tanks ...	19	5	50
Watertight bulkheads	16	—	46
„ doors	16	12	48
„ floors	5	3	36
„ tunnels	17	—	48
Wedges, hatchway	23	5	55
Welded seams, bottom plating	7	4	40
Windlass	33	6	63
Wood sheathing	11	6	43
Workmanship	32	—	61

PROPORTIONS:- SINGLE DECKERS

(1) UP TO $L/D = 14$. AREA SHOULD BE OBTAINED IN THE USUAL WAY.

(2) $L/D = 14$ TO 16. AREA SHOULD BE OBTAINED BY USING THE CORRECTIONS APPROPRIATE TO D, d AND B. THE AREA SO OBTAINED SHOULD BE MULTIPLIED BY THE FACTOR $1 + k(L/D - 14)$ WHERE k IS AS GIVEN BELOW :-

L	k
100	·15
150	·14
200	·13
250	·12
300	·11
350	·10

RULES FOR THE CONSTRUCTION OF STEEL SHIPS.

* For ships of abnormal breadth such as dredgers & floating cranes a virtual $B = 2\frac{1}{2} D$ may be used for determination of scantlings.

Section 1.

GENERAL.

1. **Determination of Scantlings.**—The scantlings in the Tables are related in general to basic dimensions and, where necessary, to a basic moulded draught. Corrections are given in the Tables, or associated Notes, for use where the actual dimensions or draught of the ship differ from those in the Tables. The Rules and Tables are framed for ships of normal ratio of breadth to depth and having proportions of length to depth at the strength deck not exceeding thirteen and a half.

(24) NORMAL RATIO OF BREADTH TO DEPTH IS LESS THAN 2·75

(25) LINEAR EXTRAPOLATION CAN BE MADE TO $L/D = 14$

If the proportions are abnormal special structural arrangements will be required.

2. **Assignment of Class.**—The class 100A will be assigned in accordance with the **General Regulations for the Classification of Steel Ships and their Machinery** to all sea-going ships when the requirements of the Rules have been complied with for the draught required.

3. **Material.**—The Rules and Tables are based on the use of mild steel which complies with the requirements of the **Rules for Quality and Testing of Materials.** Where Special Quality Steel or other material is used the scantlings will be specially considered.

The scantlings of rolled sections in the various Tables are based on the British Standards as revised in 1924.

4. **Method of Construction.**—The Rules and Tables set forth requirements for riveted construction together with certain modifications where electric arc welding is adopted. The **Rules for Electric Arc Welding in Ship Construction** are to be complied with where applicable.

SEE NOTICE No. 1948

5. **Interpolation.**—For dimensions and draughts between the values given in the Tables the scantlings are to be obtained by interpolation.

6. **Distribution of Material.**—The scantlings given in the Tables for the midship portion of the ship are to be reduced gradually to those given for the ends.

7. **Equivalents.**—Alternative arrangements or fittings which are considered to be equivalent to the requirements of the Rules will be accepted by the Committee but the Owners' sanction may be required.

8. **Submission of Plans.**—For each ship proposed to be built under survey for classification in the Register Book plans of Midship and Longitudinal Sections, on which the designed summer moulded draught is to be given together with the particulars necessary for calculation of freeboard, are to be submitted for approval.

The following plans are also to be submitted :—

Shell Plating.
Decks.
Watertight Bulkheads.
Pillars and Girders.
Deep Tanks.
Oil Fuel Bunkers.
Arrangements to resist Panting.
Strengthening of Bottom Forward.
Rudder and Sternframe.
Propeller Brackets.
Bossed Framing.
Motor and Thrust Seating.
Cruiser Stern.
Long Deckhouses.
Hatchways.
Main Steering Gear of Rod and Chain Type and Auxiliary Steering Gear.
Strengthening for Navigation in Ice.
Pumping Arrangements.
Scheme of Riveting.
Scheme of Welding.

Section 2.

DEFINITIONS.

(34) NO CORRECTION TO BE MADE FOR RAKE OF STEM.
(48) WHERE SIMPLEX RUDDER IS FITTED, LENGTH MEASURED TO AFTER SIDE OF PARTIAL BACKPOST.

1. **The Length L** is the distance in feet on the summer load water line from the fore side of stem to the after side of rudder post, or to the centre of rudder stock if there is no rudder post, but **L** is not to be less than 96 per cent of the extreme length on the summer load water line.

Amidships is to be taken as the middle of the length **L**.

2. **The Breadth B** is the greatest moulded breadth in feet.

3. **The Depth D** is measured in feet at the middle of the length **L** from top of keel to top of deck beam at side.

(*a*) **D for Shell and Topside Plating** is measured to the Strength Deck as defined in **clause 7** below.

(95) (*b*) **D for Framing** is measured to the uppermost continuous deck, BUT NOT MORE THAN 1·5 *d*.

4. **The Draught d** is the summer moulded draught in feet.

5. **The Depth h** for framing is measured in feet from the top of the double bottom or single bottom floor at side to the top of beam at side of the lowest deck.

6. **An Effective Superstructure** is a midship superstructure extending from side to side of the ship and exceeding ·15L in length.

7. **The Strength Deck** is the uppermost continuous deck except in way of an Effective Superstructure where the superstructure deck is to be considered the strength deck.

Section 3.

KEELS, STEMS AND STERNFRAMES.

1. **Materials.**—(*a*) Steel castings are to comply with the requirements of **Section 9** of the **Rules for Quality and Testing of Materials.**

(*b*) Forgings made of Ingot Steel are to comply with he requirements of **Section 10** of the above Rules.

(*c*) If forgings are made from scrap material, either iron or steel scrap may be used, but a mixture of iron and steel is not permitted.

2. **Plate Keels.**—The scantlings of plate keels are given in **Table 14.** Plate keels are to be associated with centre keelsons or centre girders as required by **Sections 4** or **5.**

3. **Bar Keels.**—The scantlings of bar keels are given in **Table 1.**

Riveted scarphs connecting the separate lengths together, or to the stem and sternpost, are to have a length of nine times the thickness of the bar.

4. **Stems.**—(*a*) Bar stems are to have the scantlings given in **Table 1,** but above the load waterline the dimensions may be gradually tapered to the stem head where the sectional area may be 75 per cent of the area derived from the Table.

(*b*) If the stem is constructed of shaped plates the thickness of the plates below the load waterline is to be 10 per cent greater than the thickness of the side shell plating (AMIDSHIPS) given in **Table 14,** Col. 8, without corrections; above the load waterline the thickness may be gradually tapered towards the stem head where it may be equal to the shell plating at ends. Plates which require to be furnaced are to have these thicknesses when finished. TUBE STEMS TABLE 14. COL 8 PER A.D. 27/3/51

The plates are to be supported by horizontal webs between the decks and below the lowest deck; the unsupported length of the stem plates is not to exceed 5 feet. Where the radius of the plates is large a centre line stiffener may be required.

For strengthening of plate stems for Navigation in Ice *see* **Section 10, clause 6.**

(*c*) The separate lengths of the stem are to be efficiently connected and the lower end of a bar stem is to overlap the forward flat keel plate.

5. **Sternframes.**—(*a*) Sternframes may be of rectangular or streamlined section or may be of built construction to suit the lines of the ship. The scantlings are to be determined from **Tables 2** and **3** and associated Notes. Cast steel and built sternframes are to be strengthened at intervals by transverse webs of suitable thickness. Cast steel sternframes are to be simple in design and all fillets should have a large radius.

(*b*) The lower part of the sternframe is to be extended forward to provide an efficient connection to the flat plate keel.

(*c*) The rudder post is to be attached to a transom plate of the same depth as that required for double bottom

UPPER PART OF RUDDER POST MAY BE REDUCED AS PERMITTED BY 1947-8 RULES; i.e. SECTIONAL AREA AT HEAD MAY BE 50% OF THAT GIVEN IN TABLE. L.O. 3/6/50.

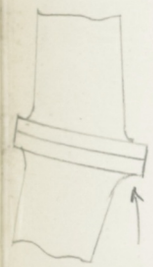
floors and ·10 inch thicker than the floors (*see* **Table 6**, Cols. 4 and 10); when the length of the ship exceeds 300 feet the rudder post is to be connected to the transom by double angles, double riveted in each flange. In single screw ships having cruiser sterns or exceeding 300 feet in length the propeller post is to be efficiently attached to a deep floor.

(*d*) The sole piece under a propeller aperture is to be kept as short as possible and is to be increased in scantlings as required by **Table 2, Note 4.**

(*e*) The upper gudgeon is to be as near as practicable to the rudder trunk and rudder coupling. Gudgeons are to have a thickness of metal round the finished bore equal to half the diameter of the pintle and the depth is to provide full bearing surface for the pintle. The scantlings of pintles are to be determined from **Table 47** and associated Notes.

DEPTH MEASURED TO BOTTOM OF LIGNUM VITAE BUSH.

(*f*) The length of the scarph in a sternframe of rectangular section is to be three times the fore and aft dimension of the post and the width of the scarph is to be half the length of the scarph. The thickness at the tip of the scarph is to be 13 per cent of the thickness of the post, and the connection is to be made by four rows of rivets. In single screw ships the scarph of the rudder post should not be fitted above the upper gudgeon. The strength of scarphs or other connections in cast steel streamlined sternframes is to be equivalent to the above requirements.



THICKNESS OF FLANGES NOT LESS THAN T2. SEE BURNTISLAND 351-2 ALSO HAMILTONS 471. 477. 492 ETC.

(*g*) The scantlings and arrangements of propeller brackets and of sternframes in ships of relatively high power will be specially considered.

For riveted connections to stems and sternframes *see* **Table 52 (G).**

Section 4.

SINGLE BOTTOMS

1. **Floor Plates.**—(*a*) **Scantlings.** The scantlings of floor plates are to be determined from **Table 4** and associated Notes. Floors are to be fitted at every frame.

If a bar keel is fitted the floors are to be continuous from side to side; if a flat plate keel is adopted the floors may be continuous or cut at the centre line.

(*b*) The floors at the bilges are to be attached to the frames by flanged brackets of the same thickness as the floor plates and having breadth and depth, clear of the frame and floor respectively, equal to the depth of the floor at the centre line.

(107) WHERE BRACKETS ARE OMITTED THE FRAME IS TO BE INCREASED AS PER TABLE 12, NOTE 2. FOR WING BKTS.

Alternatively, the brackets may be omitted if the depth of the floor is increased by 15 per cent and the frame is reinforced at its junction with the floor plate.

SEE NOTE ~~65~~ 64 (SECTION 34) RE TUGS AND TRAWLERS.

(*c*) The tops of floors are, in general, to be level from side to side but in ships having considerable rise of floor, and in all ships in the engine room and towards the ends, the depth of the floor plates is to be increased; the brackets may be dispensed with provided the side framing is adequately supported.

(*d*) Floor plates forming part of a bulkhead are not to be less than 36 inches in depth measured at the centre line and the thickness is to be as required for the bottom strake of the bulkhead.

(*e*) The side frames are to be efficiently attached to the floor plates.

2. **Frames and Reversed Frames.**—(*a*) Floors are to be attached to the bottom plating by single angles having the same thickness as the floor plates. (*See also* **Section 8, clause 4.**)

(*b*) Reversed frames on the upper edges of the floor plates are to have the scantlings given in **Table 4.**

Throughout the engine room, under the boiler bearers and in way of strengthening of bottom forward, the reversed frames are to be doubled from side to side.

3. **Centre Keelsons.**—(*a*) **Scantlings.** The scantlings of centre keelsons are given in **Table 5.** The keelsons are to extend as far forward and aft as practicable, and where cut at bulkheads the longitudinal strength is to be efficiently maintained.

(*b*) In ships having a bar keel, the centre keelson is to consist of continuous double angles on top of the floors in conjunction with intercostal plates connected to the floors by single angles having the same thickness as the intercostal plates.

In ships not exceeding 160 feet in length the intercostal plates may be omitted provided the centre keelson bars are as required by **Table 5** for Tugs.

(*c*) Plate keels are to be associated with plate keelsons having double continuous top angles. The keelson plates are to be connected to the keel by single angles except in the engine room, thrust recess and the forward ·25L where the connection is to be double. If the floors are continuous the keelson plates are to be intercostal and attached to the floors by single angles having the same thickness as the intercostal plates.

Where the floors are cut at the middle line they are to be connected to the continuous keelson plate by double angles

FRAME RIVETS CLOSED UP AS ALTERNATIVE TO REINFORCEMENT BURNTISLAND 341, 342-3. 356. ETC.

having the thickness of the keelson plates. Continuous foundation plates are to be fitted at the top of the floors on each side of the keelson plate.

(*d*) The butts of all continuous longitudinal material are to be efficiently strapped or welded.

4. **Side Keelsons.**—(*a*) **Scantlings.** The scantlings of side keelsons are given in **Table 5.** The keelsons are to extend as far forward and aft as practicable, and where cut at bulkheads the longitudinal strength is to be efficiently maintained.

(*b*) One side keelson is to be fitted on each side of the centre line if the breadth B does not exceed 30 feet and two where B is above 30 feet and does not exceed 54 feet.

(*c*) The keelsons are to consist of a continuous angle with the wider flange faying on the reversed frames.

Intercostal plates fitted between the floors are to be attached to the continuous angles and connected to the shell plating by single angles having the same thickness as the intercostal plates.

(*d*) The butts of the continuous angles are to be efficiently strapped or welded.

(*e*) In the Engine Room additional side keelsons are to be fitted.

5. **Increased thickness in Machinery Spaces.**—In the Engine Room the floors are to be increased in thickness by ·04 inch.

In the Boiler Room the floors, reversed frames, centre and side keelson plates and all angles not covered by cement are to be increased in thickness by ·10 inch.

6. **For strengthening of bottom forward,** *see* **Section 8.**

7. **Ships Loading or Discharging aground.**—It is recommended that the bottoms of small ships intended to load or discharge aground be additionally strengthened in order to withstand the exceptional stresses to which they may be subjected.

8. **Pumping and Drainage** arrangements are to be in accordance with the requirements of the **Rules for Pumping and Piping.** Efficient provision is to be made to permit water from every part of the bottom to reach the pump suctions.

Section 5.

DOUBLE BOTTOMS.

1. **Scantlings.**—The scantlings of the double bottom structure and the tank side connections are to be determined from **Tables 6** to **11** and associated Notes.

2. **Centre Girder.**—The attachment of the centre girder to the keel plate and to the middle line strake of the inner bottom is to be by double angles, or equivalent connections, throughout in all ships exceeding 350 feet in length; in smaller ships the attachment need be double, or equivalent, only in the engine room, thrust recess and in the forward ·25L.

3. **Intercostal Side Girders.**—(*a*) In ships where the breadth B does not exceed 34 feet one stiffener is to be fitted to the floors on each side, about midway between the centre line and the margin plate. Where B exceeds 34 feet one intercostal side girder is to be fitted and where B exceeds 64 feet but does not exceed 80 feet two girders are to be fitted on each side of the centre line extending as far forward and aft as practicable. In the forward ·25L of all ships side girders are to be fitted as required by **Section 8, clause 3** (*c*).

(*b*) In the machinery space and thrust recess the number and disposition of the side girders are to be such as to support the machinery effectively and to secure the necessary rigidity of structure. Double angles or equivalent connections are to be fitted on the upper edges of these girders under the engines and thrust seating.

(*c*) Intercostal girders are not to be flanged in the forward ·25L, under the engine and thrust seating or under widely spaced pillars. Where intercostals are flanged their thickness is to be increased by 10 per cent.

(*d*) If plate floors are fitted at every frame the intercostal girders, except in the engine room and in the forward ·25L, may be replaced by continuous bulb angles on the shell and inner bottom having the scantlings given in **Table 10** for a span of 4 feet.* These bulb angles are to be attached to the floors by vertical angles, extending for the full depth of the floors, having the same depth as the bulb angles, but the depth need not exceed 6 inches. The thickness of the vertical angles may be the same as that of the floors.

Riveting at each end of the vertical angles is to be as required by **Table 8,** Cols. 4 and 5.

4. **Plate Floors.**—(*a*) Plate floors are to be fitted at every frame in the engine room and in the forward ·25L;

they are also to be fitted under the boiler bearers, bulkheads, toes of brackets to deep tank bulkhead stiffeners and in way of any change in depth of double bottom. Partial plate floors are to be fitted under the thrust seating.

The floors under the engine room, thrust seating and boiler bearers are to have double angles or equivalent attachments to the centre girder; elsewhere the connections may be single. The reversed frames on the floors may be single except under the engine room from the centre line to the girder outside the engine seating, under the thrust seating and from side to side under boiler bearers.

(*b*) Except as required by (*a*) above, plate floors may be spaced not more than 10 feet apart, and the shell and inner bottom plating between these floors is to be supported by bracket floors. Alternatively a system of longitudinal framing may be adopted—*see* **clause 6.**

(*c*) Floors are not to be flanged.

(*d*) Watertight floors are to be fitted below or in the vicinity of watertight bulkheads and their thickness is to be ·08 inch greater than that given in **Table 6,** Col. 10, but need not exceed ·54 inch. If the depth of the centre girder exceeds 36 inches the floors are to be fitted with stiffeners, of scantlings given in **Table 9,** spaced 30 inches apart; the ends of the stiffeners are to extend to the toes of the boundary angles.

(*e*) Additional stiffening is to be fitted under the heels of widely spaced pillars as required by **Section 15, clause 7**

(*f*) In ships engaged in heavy trades such as ore carrying, or in ships from which the cargo is to be regularly discharged by grabs, it is recommended that plate floors be fitted at every frame.

5. **Bracket Floors.**—(*a*) The scantlings of the bottom frames and reversed frames are to be determined from **Table 7** and associated Notes.

(*b*) The breadth of the brackets attaching the frames and the reversed frames to the centre girder and margin plate is to be three-quarters of the depth of the centre girder; the brackets are to be flanged on the unsupported edge and are to have the same thickness as the plate floors.

(*c*) The frames and reversed frames are to be attached to the side girders by angles having the same depth as the reversed frames, but these angles need not exceed 6 inches in depth. The thickness of the vertical angles may be the same as that of the floors.

(59) STIFFENERS TO BE FITTED TO SIDE GIRDERS ABOUT 4 FT APART.

Struts, if fitted to reduce the unsupported span of the frames and reversed frames, are to have the scantlings given in **Table 8.** Where the struts are welded the area is to be at least 80 per cent of that given in **Table 8,** Col. 6, provided their stability and end connections are adequate.

(*d*) Details of riveted connections in bracket floors are given in **Table 8.**

6. **Longitudinal Framing.**—(*a*) Where longitudinal framing is adopted in the double bottom the scantlings of the longitudinals are to be as given in **Table 10** and associated Notes.

(*b*) The spacing of the plate floors is not to exceed 12 feet and the thickness of the floors is to be increased 10 per cent beyond that required by **Table 6.**

(*c*) The floors are to be attached to the shell and inner bottom by double angles or equivalent for two spaces of longitudinals at each end of the floor plate. The floors are to be attached to the centre girder and margin plate by double angles single riveted, or equivalent, except where the spacing of the floors exceeds 8 feet when the attachment to the centre girder is to be by double angles double riveted.

(*d*) The unsupported span of the longitudinals is not to exceed 8 feet. In longer spans struts of the same scantlings as required for bracket floors (**Table 8**) are to be introduced and attached to the longitudinals by the number of rivets given in the Table.

(60) IF COMPLETE PLATE (FLANGED) FITTED CONNECTING TOP & BOTTOM LONGLS TO W.T. FLOORS SPAN MAY BE MEASURED TO FACE OF BRACKET. IF SPAN MEASURED TO FLOOR FACE PLATE MAY BE SCALLOPED OUT.

The shell and inner bottom longitudinals are to be attached to the floors by means of vertical angles extending from the shell to the inner bottom having the same depth as the inner bottom longitudinals, but these angles need not exceed 6 inches in depth; they are to be riveted as required by **Table 8.** The thickness of the vertical angles may be the same as that of the floors.

Where longitudinals are cut at watertight floors they are to be attached to the floors by brackets of a width on each arm equal to three times the depth of the shell longitudinals, of the thickness given in **Table 6,** Col. 10 or 11, and riveted as required by **Table 8,** Cols. 7 and 8.

(*e*) An intercostal side girder, as required by **clause 3,** is to be fitted on each side where B exceeds 45 feet and two side girders on each side where B exceeds 70 feet.

(7) INCREASE IN LONGL FRAMING ACCEPTED AS COMPENSATION FOR OMISSION OF SIDE GIRDERS.

(*f*) Between plate floors, transverse brackets of the thickness required by **Table 6,** Col. 10 or 11, are to be

MAY BE MEASURED FROM MID-DEPTH OF SLOPING MARGIN PROVIDED THIS GIVES ADEQUATE ATTACHMENT OF REVERSE FRAME. PER J.M.M. L.O. 12/9/50

SPACING OF SHELL RIVETS 4½ DIAS: 4 DIAS IN WAY OF S.O.B. FORWD. SEE TABLE 52B NOTE 5.

GUSSET PLATES SAME THICKNESS AS TANK SIDE BRACKETS. (SEE TABLE 11)

fitted extending from the centre girder and margin plate to the adjacent longitudinal. The brackets, which are to be flanged, are to be fitted at every frame at the margin plate and those at the centre girder are to be spaced not more than 4 feet apart.

(*g*) Where, at the ends of the ship, the longitudinal system of framing is replaced by a transverse system adequate arrangements are to be made to avoid abrupt discontinuities.

7. **Inner Bottom Plating and Margin Plates.**—(*a*) The inner bottom plating is to be of the thickness given in **Table 6** and is to be increased by ·08 inch under the hatchways if no ceiling is fitted; the thickness of the middle line strake is not to be less than that of the increased inner bottom plating.

The margin plate is to have the thickness given in **Table 6** and is to be of the depth amidships required by **Table 6, Note 2.**

(*b*) If cargo is to be regularly discharged by grabs, or similar means, it is recommended that double ceiling should be fitted or the thickness of the plating increased ·20 inch and fitted with a flush surface.

8. **Manholes and Lightening Holes.**—(*a*) Sufficient manholes are to be cut in the inner bottom, floors and side girders to provide adequate ventilation and access to all parts of the double bottom and the edges of the holes are to be smooth. No manholes are to be cut in the floors or girders under widely spaced pillars.

(*b*) Where manhole covers are attached by bolts to the inner bottom plating, doubling plates or rims are to be fitted to take the fastenings of the covers. Manhole covers which project above the inner bottom plating are to be adequately protected.

9. **Tank Side Brackets and Margin Connections.**—(*a*) The height and thickness of the tank side brackets are given in **Table 11.** The free edges of the brackets are to be flanged or otherwise stiffened.

At the ends of the ship where the form of the brackets may become unduly elongated, the arrangements will be specially considered.

(*b*) Riveted attachments of the tank side brackets to the frames and margin plate are given in **Table 11.** The angles attaching the floors to the margin plate are to have the same number of rivets in both flanges as the angle to the tank side brackets, and the inner and outer angles are to be through riveted.

SEE LETTER FROM J.M.M. 13/9/49

If gusset plates are fitted they are not to be more than three frame spaces apart; if the number of rivets required in the gusset is more than six per frame space the gusset is to be fitted at every frame or is to be a continuous plate. Gussets are to be so spaced that each will require not less than three rivets.

(*c*) If the margin plate is approximately horizontal the strength of the margin connection will be specially considered.

(*d*) For increases in the panting region *see* **Section 9, clause 3** (*b*).

10. **Increased Thicknesses in Machinery Spaces.**—(*a*) In the boiler room and donkey boiler recess the floor plates and brackets, centre and side girders, inner bottom plating, margin plate, tank side brackets, gussets and all rolled sections not covered by cement, and in the engine room the inner bottom plating, are to be increased in thickness as required in **Tables 6** to **11** and associated Notes.

INCREASES NOT REQUIRED IN SCOTTS 655-6 (L.R. 26-5-50) BURNTISLAND 343 & 344.

(*b*) Where machinery is fitted aft, the thicknesses of the inner bottom plating in the boiler room are to be increased by the increments which would have been added if the machinery had been fitted amidships; in the engine room this thickness is to be as given in **Table 6,** Col. 18.

11. **Strengthening of Double Bottom Forward** is to be in accordance with the requirements of **Section 8.**

12. **Ships Loading and Discharging Aground.**—It is recommended that the bottoms of small ships intended to load or discharge aground be additionally strengthened in order to withstand the exceptional stresses to which they may be subjected.

13. **Oil Fuel.**—If oil fuel is to be carried in double bottoms the provisions of **Section 20, clause 10** are to be complied with.

Where **Refrigerated Cargoes** are to be carried, *see* **Section 20, clause 11.**

14. **Pumping and Drainage.**—(*a*) The arrangements are to be in accordance with the requirements of the **Rules for Pumping and Piping.**

(*b*) Ample provision is to be made for the free passage of air and water from all parts of the tanks to the air pipes and suctions.

15. **Caulking and Water Testing.**—The double bottom is to be caulked and made watertight, but the centre girder need not be caulked or tested.

Each compartment on completion is to be tested with a head of water representing the maximum pressure which could be experienced in service.

For additional stiffening under heels of pillars, *see* **Section 15, clause 7** (*e*).

Section 6.

SIDE FRAMING.

1. **Scantlings.**—(*a*) The scantlings of the main, peak and 'tween deck frames are to be determined from **Tables 12** and **13** and associated Notes. The depth D for use in the Tables is defined in **Section 2, clause 3** (*b*).

(*b*) The scantlings given for the framing in the various 'tween decks represent the minimum standard, but the system is to be arranged so that continuity is maintained.

(*c*) Where holes are drilled or punched in the inboard flange of channel or similar hold frames, the scantlings may have to be increased.

2. **Frame Spacing.**—(*a*) The spacing of the frames, except in the regions defined in (*b*) and (*c*) below, may be as given in **Tables 12** and **13.**

(*b*) Frame spacing in peaks and cruiser sterns is not to exceed the Table spacing or 24 inches, whichever is less.

(*c*) Frame spacing between ·2L from forward and the collision bulkhead is not to exceed the Table spacing or 27 inches, whichever is less.

(*d*) Where the spacings adopted differ from those set forth above, the scantlings of the main and 'tween deck frames are to be corrected as required by the Notes.

3. **Main Framing.**—The depth h to be used in **Table 12** is defined in **Section 2, clause 5,** and is to be measured :

At amidships, for framing between the after peak bulkhead and ·25L from the fore end.

At ·25L from the fore end, for framing between that point and ·15L from the fore end.

As required by **Section 9, clause 3** (*a*) for framing between ·15L from the fore end and the collision bulkhead.

4. **Framing in 'Tween Decks and Superstructures.**—(*a*) In 'tween decks marked B (*see* **Notes** to **Table 13**) between ·12L from the after end and ·2L from the fore end and in detached superstructures, frames may be fitted two frame spaces apart provided the main frame spacing does not exceed 30 inches and the ratio of that spacing in inches to the minimum thickness of the 'tween deck side plating does not exceed 55 in ships 300 feet or less in length and 45 in ships 500 feet or more in length, with intermediate values in proportion.

(*b*) At each end of a bridge four frames are to extend from the 'tween deck below to the bridge deck.

(*c*) 'Tween deck and superstructure frames are to be efficiently scarphed to the main frames below or effectively attached to the deck, except in the poop where the lower ends of the intermediate frames (if fitted) need not be attached.

5. **Cruiser Sterns** are to have frames of size required in peaks, and are to be additionally stiffened by web frames where required. The floor plates are to be of a reasonable depth, and are to be associated with a middle line girder.

6. **General.**—(*a*) Floors in fore and after peaks are to have a thickness ·04 inch greater than required for floors in a double bottom. In after peaks the floors are to extend well above the stern tube, or, if this is impracticable, cross-tie plates flanged on both edges are to be fitted above the stern tube. Rivets connecting floors and cross-tie plates to the frames are to be spaced not more than five diameters apart. (*See* **Section 9, clause 4.**)

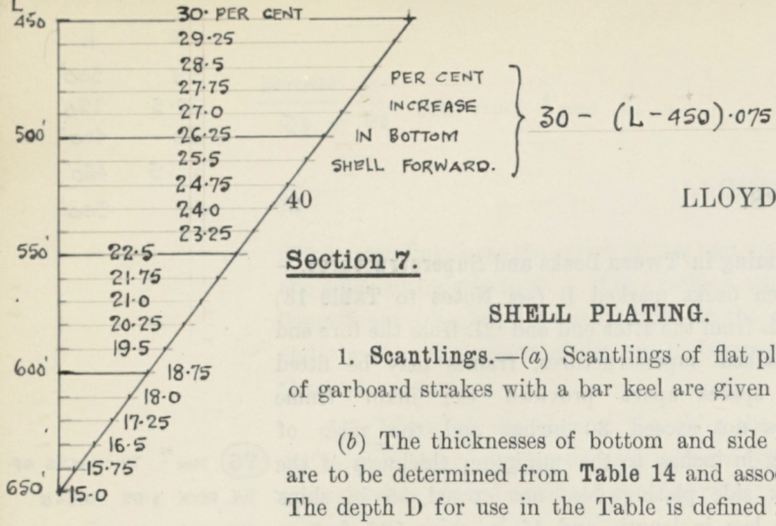
(*b*) In boiler rooms and permanent coal bunkers the thickness of the framing is to be increased ·06 inch beyond that derived from the Tables.

(*c*) Where the depth of the framing is reduced adequate stiffness is to be maintained.

(*d*) The breadth of the shell flange of the frames is to be suitable for the diameter of rivet used.

(*e*) For framing in deep water ballast tanks, in oil fuel bunkers and in machinery spaces, *see* **Sections 19, 20** and **22.**

Section 6



Section 7.

SHELL PLATING.

1. **Scantlings.**—(*a*) Scantlings of flat plate keel and of garboard strakes with a bar keel are given in **Table 14.**

(*b*) The thicknesses of bottom and side shell plating are to be determined from **Table 14** and associated Notes. The depth D for use in the Table is defined in **Section 2, clause 3** (*a*).

(*c*) In way of an Effective Superstructure the thickness of bottom and side plating may be based on D measured to superstructure deck, but clear of the superstructure D is to be taken to the uppermost continuous deck. The thicker plating is to be suitably extended within the ends of the superstructure to ensure continuity of strength. (*See also* **clause 5** below.)

(*d*) The scantlings of the sheerstrake are to be in accordance with **Table 18** and **Section 11, clause 1** (*a*).

2. **Openings in Shell Plating.**—(*a*) All openings in the shell plating for cargo doors, inlets, or other purposes, are to have well rounded corners, and arrangements are to be made to maintain the strength in way of the openings; the plating is to be reinforced in way of hawse pipes.

(*b*) Where side scuttles or other openings are cut in the sheerstrake, removing more than 20 per cent of the Rule sectional area of the unpierced plate, compensation is to be provided.

* RANGE FOR THIS INCREASE EXTENDED TO 250'. THIS APPLIES ONLY TO SHIPS IN WHICH MACHRY IS FITTED AMIDSHIPS. WHERE MACHRY IS FITTED AFT, CASE SHOULD BE SUBMITTED TO L.O. L.O. 11/11/49.

3. **Shift of Riveted Butts.**—The butts of shell plates and those of sheerstrake and stringer plates are to be arranged to give as good a shift as practicable; in adjoining strakes butts are to be generally at least two frame spaces apart.

The butts of the sheerstrake are to be at least two frame spaces from those of adjacent deck stringer plates.

4. **Welded Seams.**—If the seams of bottom plating are butt-welded an increase in the thickness of the bottom plating may be required.

5. **Continuity of Strength** is to be maintained at the break of superstructures as required by **Section 12, clause 3,** and **Section 13, clause 3.**

Section 8.

STRENGTHENING OF BOTTOM FORWARD.

1. **Extent.**—The bottom structure is to be strengthened between ·05L and ·25L from the fore end. A sketch showing sections in way of the bottom forward is to be submitted.

(61) SHELL PLATING IN WAY OF BOTTOM FOR° TO BE CORRECTED FOR FRAME SPACING. BETWEEN ·2 AND ·20L CORRECT RELATION TO TABLE 14 COL 4: AND FROM ·2 TO COLLISION BHD RELATE TO COL 4 OR 27" WHICHEVER IS LESS

2. **Shell Plating.**—The thickness of the three strakes next to the keel plate, or, in small ships, two strakes provided these cover the flat of bottom, is to be that given in **Table 14,** Col. 10, increased by 30 per cent where the length of the ship does not exceed 450 feet and 15 per cent where the length is 650 feet; the increase at intermediate lengths to be in proportion. In ships with machinery aft not exceeding 300 feet in length the increase is to be 40 per cent and the keel plate is not to be less in thickness than the adjacent bottom plating.

(92) INCREASE TO THICKNESS OF BOTTOM FOR° WHEN FLOORS WELDED TO SHELL ·02" AT 150' TO ·04" AT 300' TO 500' (SEE NOTE (71))

The midship thickness of the above strakes is to be carried forward to the increased plating.

If the floors are welded directly to the bottom plating the latter is to be increased in thickness.

3. **Double Bottoms.**—(*a*) Floors and intercostal girders are not to be flanged.

(*b*) Plate floors are to be fitted at every frame and are to be connected to the bottom plating by double angles, or equivalent connections, extending from margin to margin, or, in single bottom ships, to lower turn of bilge.

F.K. SYSTEM SEE NOTES (76) AND (89)

(*c*) The intercostal side girders are not to be more than 7 feet apart, the plating between them being supported by additional half-height intercostal girders carried as far forward as practicable.

(77) BOTTOM LONGITUDINALS TABLE 10 FOR 8FT SPAN SPACED 27" CORRECTED IF NECESSARY FOR VARIATION FROM

(*d*) Where longitudinal framing is adopted in the double bottom the arrangements are to include plate floors fitted on alternate frames between ·05L and ·25L from the fore end and the spacing of longitudinal framing in this region is to be in accordance with the requirements of **Section 6, clause 2** (*c*).

4. **Single Bottoms.**—The reversed frames are to be doubled and additional intercostal girders are to be fitted; in other respects the requirements for double bottoms are to be carried out where they apply.

WHERE SINGLE ANGLE, DOUBLE RIVETED, RIVS MAY BE 6¼" DIAS APART.

5. **Riveting.**—The rivets in both flanges of the frame angles are to be spaced 5½ diameters apart. The diameter of rivets in butts and seams of bottom plating is to be appropriate to the increased thickness of the plating, and the seams are to be double riveted.

GENERALLY NOT TO BE INCREASED.

(76) WITH F.K. SYSTEM INTERMEDIATE FRAMES TABLE 10 FOR 4 FT SPAN LESS 25% SIDE GIRDERS TABLE 6. COL 10: SHELL SECT 8 COL 2, EXCEPT INCREASES TO BE 20% AT 450 FT AND 10% AT 650 FT.

(89) WITH F.K. SYSTEM, FULL HEIGHT AND HALF ~~GIRDE~~ HEIGHT GIRDERS NOT CONNECTED TO THE SHELL SHOULD BE FITTED.

Sections 7-8

(71) L BETWEEN 350' AND 500' FOR ·4 L NOT APPLICABLE WITH LONGL. FRAMING.
(i) + 9% IF SEAMS WELDED.
* (ii) + 18% IF SEAMS WELDED & FLOORS WELDED TO SHELL.
L UP TO 500' BOTTOM FORWARD + ·04" (ASSUMED TO APPLY ONLY WHEN FLOORS WELDED. NO INCREASE FOR ½ L FOR
SEE ALSO NOTE (92) (SECTION 8 CL 2)

INCREASES FOR STRINGERS SPACED MORE THAN 6'0 APART. [LITHGOW'S 10'0". 7'3" SPACING]

(a) SIDE FRAME MODULUS INCREASED DIRECTLY AS SPAN. [CONNELL'S 473. 7'3" "]

(b) SIDE SHELL INCREASED BY 6¼%. (HALF OF INCREASE PROVIDED FOR IN DECISION (94)) IRRESPECTIVE OF STRINGER SPACING.

(c) WIDTH OF STRINGERS INCREASED 2" FOR 1FT INCREASED SPACING OF STRINGERS.

Section 9.

ARRANGEMENTS TO RESIST PANTING.

1. **Extent.**—The structure is to be strengthened to resist panting for ·15L from the fore end and abaft the after peak bulkhead.

2. **Forward of the Collision Bulkhead.**—(*a*) Tiers of beams spaced 6 feet apart are to be fitted to alternate frames below the lowest deck and are to have the scantlings given in **Table 15.**

(*b*) Stringer plates of the scantlings given in **Table 16** are to be fitted at each tier of beams. The stringer plates are to have double attachments to the shell plating. Alternatively, stringer plates of Table scantlings may be fitted inside the frames without attachment to the shell plating provided the stringer plate is stiffened on both edges, and the thickness of the shell plating is 10 per cent greater than the thickness given in **Table 14,** Col. 9, where the length of the ship does not exceed 150 feet and 25 per cent where the length is 350 feet or above; the increase at intermediate lengths is to be in proportion.

(*c*) Frames to which a beam is not fitted are to be attached to the stringer plate by brackets, having the same thickness as the beam knees and a depth of one half the breadth of the stringer plate.

3. **Abaft the Collision Bulkhead.**—(*a*) The strength of the side frames below the lowest deck for the distance defined in **clause 1** is to be increased 20 per cent above that derived from **Table 12,** the value of h for use in the Table being the maximum between ·15L from the fore end and the collision bulkhead, measured as defined in **Section 2, clause 5.**

(*b*) The strength of the attachment of the frames to the tank side brackets, of the tank side brackets to the margin plates and gussets, and of the gussets to the margin plate is to be increased by 20 per cent above the requirements of **Table 11.** The connection of the floors to the margin plate is to be the same as the connection of the tank side brackets to the margin plate, and, where riveted, the connecting angles inside the tank are to be on the same side of the floor as the outside connections, to take through rivets.

(*c*) Side stringers of the scantlings given in **Table 16** are to be fitted in line with those forward of the collision bulkhead and are to extend aft for the distance defined in **clause 1**; they are to be attached to the shell by single riveted angles.

The side stringers may be omitted provided the shell plating is increased by the percentages given in **clause 2** (*b*).

4. **Abaft the After Peak Bulkhead.**—The structure is to be efficiently stiffened by deep floors and tiers of beams in association with stringers as required in the fore peak (**Tables 15** and **16**) except that these may be spaced 8 feet apart. In twin screw ships the frames abaft the propeller brackets and up to the lowest deck are to be attached to the shell plating by two rows of rivets or equivalent connections. (*See* **Section 6, clause 6** (*a*).)

Special arrangements may be required in single screw ships of high speed.

If, on account of the ship's form, the unsupported length of the frames exceeds 8 feet, additional stiffening may be required.

5. **Deep 'Tween Decks.**—If necessary, in ships with deep 'tween decks additional intercostal side stringers supported by web frames are to be fitted at the forward and after ends. The stringers may be omitted provided the thickness of the shell plating is suitably increased.

Section 10.

STRENGTHENING FOR NAVIGATION IN ICE.

1. **Framing.**—(*a*) Forward of the collision bulkhead intermediate frames having the scantlings given in **Table 17** are to be fitted, extending from below the level of the floors to the deck next above the water line.

(*b*) Abaft the collision bulkhead the main frames for a distance from the stem equal to ·15L are not to be less than required by **Section 9, clause 3,** for a ship having a draught of ·06L.

Intermediate frames having the scantlings given in **Table 17** are to be fitted for a distance from the stem equal to ·10L+25 feet, but this distance need not exceed 65 feet. These intermediate frames are to extend from the margin or from below the top of the single bottom floors to the deck next above the load water line; they need not be connected at their ends.

(*c*) The breadth of the shell flange of the frames is to be suitable for the riveting required by **clause 4** below.

(51) INCREASE TO SIDE SHELL IF STRINGERS OMITTED APPLIES TO SIDE PLATING ONLY & NOT TO SHEERSTRAKE.

(79) IN SMALL SHIPS INCREASE LIMITED TO 1 OR 2 STRAKES.

(79) IN SMALL SHIPS INCREASES LIMITED TO ONE OR TWO STRAKES.

(33) NUMBER OF RIVETS IN BKTS, SAME AS IN ADJACENT BEAM KNEE (i.e. WHEN STRINGER NOT ATTACHED TO SHELL) WHEN STRINGER IS ATTACHED TO SHELL, INT. KNEES TO BE ½ DEPTH OF STRINGER AND N° OF RIVS AS REQUIRED BY TABLE 15 FOR ½ DEPTH. PER E.P. 14-1-49.

(94) THE ADDITIONAL THICKNESS IS TO BE FITTED WHERE FRAMING D AND E IS REQUIRED AND IS TO BE HALF THAT GIVEN IN CL. 2 (b)

(84) EXTENT NEED NOT EXCEED L/4

CORRECT FOR DRAUGHT BUT NOT FOR SPACING. BURNTISLAND 356.

2. **Panting Arrangements.**—The requirements of **Section 9** are also to be complied with, and the strength and stiffness of the framing system are not to be less than required for the actual draught of the ship.

3. **Shell Plating.**—The thickness of the shell plating is to be increased from the stem to a position as far aft as the extent of the reinforced framing between 1 foot above the load water line and 2 feet below the light water line.

The thickness is to be 65 per cent greater than the minimum given in **Table 14,** Col. 11, but need not exceed 1 inch.

The shell plate in each strake immediately abaft the increased plating is to be intermediate between the full thickness required above and the normal thickness of side shell plating.

4. **Riveting.**—The diameter of the rivets used may be $\frac{1}{8}$ inch less than that required by **Table 52 (A)** for the increased thickness of plating. The seams of the increased shell plating are to be double riveted.

5. **Stringers.**—Stringers of the scantlings shown in **Table 16** spaced 6 feet apart are to be fitted forward and aft of the collision bulkhead. They are to be carried aft to the position at which the shell becomes of normal thickness.

6. **Plate Stems.**—The thickness of the plates below the load water line is to be 65 per cent greater than the thickness given in **Table 14,** Col. 11, without correction, but need not exceed 1 inch; above the waterline the thickness may be tapered to that of the normal plate stem (*see* **Section 3, clause 4** (*b*)). Plates which require to be furnaced are to have these thicknesses when finished. The spacing of the horizontal webs below the load water line is not to exceed 3 feet.

(66) ½" ON PINTLES FOR ICE STRENGTHENING.

7. **Rudder and Steering Arrangements.** — The diameter of the rudder head is to be 1 inch greater than required by **Table 44.** The scantlings of the rudder, the dimensions of the quadrant and tiller and the diameter of steering rods and chains are to be in accordance with the increased rudder head.

8. **Screw Shaft.**—The diameter of the screw shaft is to be increased 5 per cent above that required by the Rules.

9. **Propeller Blades** are to be made of cast steel or other approved material. If bronze is used for propellers or blades it is to comply with the requirements of **Section 11** of the **Rules for Quality and Testing of Materials.**

10. **Sea Valves** for inlet or discharge below the load water line are to be provided with connections from the boiler, or air receiver if there is no boiler, for clearing purposes. The scantlings of the valves are to be suitable for the maximum pressure to which they will be subjected, and the valves are to be made of steel or other approved material. Steel valves are to be suitably protected against wastage.

Section 11.

DECKS.

1. **Plated Decks.**—(*a*) Strength deck and sheerstrake scantlings are to be determined from **Table 18** and associated Notes. The depth D for use in the Table is defined in **Section 2, clause 3** (*a*). Strength deck requirements are tabulated for ships having one, two or three decks. If there is more than one deck the sectional area of the strength deck given in **Table 18** is that required when the scantlings of the lower decks are in accordance with **Table 20.**

(*b*) Scantlings for Effective Superstructures, as defined in **Section 2, clause 6,** are also to be determined from **Table 18,** the depth D being measured to the superstructure deck. (*See also* **Table 18, Note 9.**)

(*c*) Minimum thicknesses of strength decks and lower decks are given in **Tables 18** and **20** respectively.

(*d*) Platform decks for which no credit is taken in determining the scantlings of the strength deck (*see* (*a*) above) are to have the scantlings given in **Table 20,** Col. 8.

(39) NO LIMIT, EXCEPT PRACTICAL CONSIDERATIONS, TO SIZE OF SHIP HAVE STRINGERS & TIES

2. **Decks with Stringer and Tie Plates.**—The scantlings of stringers and tie plates fitted under a wood deck are to be determined from **Table 18, Note 10,** and **Table 20, Note 5.**

Tie plates are to be fitted at each side of the hatchways and are to be continuous; where these form the upper members of girders supported by widely spaced pillars they are to be suitably increased. Cross ties are to be arranged at the ends of hatchways and other openings. The decks are to be plated over abreast machinery openings, the plating being tapered into the stringer plates beyond the openings.

(85) SUPERSTRUCTURE ON SUPERSTRUCTURE :-
FRAMING - TABLE 13 ; IF DIAG I, COL A, BUT MINIMUM (AFTER ALL CORRECTIONS) 70% COL F.
IF DIAG II USE COL F UNCORRECTED.
SIDE PLATING - IF LENGTH SUFFICIENT TO ENTER INTO MAIN STRENGTH USE
TABLES 14 AND 18. IF SHORT, USE TABLE 21
AND REDUCE SIDE PLATING BY 10%, WHERE $\frac{d}{D}$ ·70 OR LESS

3. **Stringer Angles.**—The butts of strength deck stringer angles are to be efficiently welded or strapped and if the angle is cut in way of scuppers compensation is be provided.

4. **Concentration of Loading.**—Additional strengthening to the decks may be required where there is indication of concentration of loading.

5. **Continuity of Strength** is to be maintained at the ends of large openings in the strength deck and the deck below by means of corner doubling plates or equivalent arrangements, and associated, if necessary, with intercostal girders at the strength deck. Special attention is to be given to workmanship at these parts.

6. **Wood Sheathing and Decks.**—The material is to be of good quality, well seasoned and free from sapwood. The thickness is not to be less than $2\frac{1}{2}$ inches for pine or 2 inches for teak.

Thwartship planks are to be laid at the ends of hatchways, deckhouses and similar boundaries.

The vertical flange of coaming or foundation angles is to extend half an inch above the wood deck. Gutterway angles or welded flats are not to be less than ·30 inch in thickness.

The planking is to be efficiently fitted. Fastenings are not to be less than $\frac{1}{2}$ inch in diameter, sunk below the surface of the planking and covered with turned dowels, the whole being thoroughly bedded in white lead or other suitable composition.

Bolts are to be galvanised; welded studs used instead of bolts are to be coated with suitable composition before the planking is laid.

All decks are to be caulked and payed.

7. **Deck Compositions.**—If an approved composition is laid as a substitute for wood sheathing the steel deck is to be caulked, made watertight and coated with a suitable material in order to prevent corrosive action between the steel and the composition. The composition is to be effectively secured to the deck.

8. **Caulking and Water Testing.**—All plated decks are to be caulked unless sheathed with a properly caulked wood deck. The spaces between frames at lower decks are to be effectively closed by cement or other means.

Weather decks and gutterways are to be hose tested on completion.

Section 12.

DETACHED SUPERSTRUCTURES.

1. **Short Superstructures.**—The scantlings of poops and forecastles, and of bridges not exceeding ·15L in length, are to be determined from **Table 21** and associated Notes.

(29) POOP OF LENGTH ·4L SHOULD BE TREATED AS A SHORT SUPERSTRUCTURE.

All seams and butts may be single riveted.

2. **Long Bridges.**—(*a*) A long bridge is an Effective Superstructure as defined in **Section 2, clause 6,** and the scantlings are to be determined from **Table 18** and associated Notes. *See also* **Section 7, clause 1** (*c*), and **Section 11, clause 1** (*b*).

Second and third deck scantlings may be reduced in way of the superstructure. (*See* **Table 18, Note 9.**)

(*b*) The riveting of butts and seams of deck plating, sheerstrake and side plating is to be as required by **Table 52** (**B** & **C**), but the side plating and sheerstrake seams are not to be less than double riveted for four frame spaces at the ends of the superstructure.

(*c*) Transverse strength is to be ensured by fitting web frames or partial bulkheads in the bridge if large deckhouses are constructed above.

(22) ALSO + 25% ON BRIDGE SHEERSTRAKE. THIS PARAGRAPH APPLIES TO LONG BRIDGES ONLY.

3. **Strengthening at Ends of Superstructures.**—The thickness of the upper deck sheerstrake is to be increased by 50 per cent and the thickness of the stringer plate by 25 per cent at the ends of long bridges. Similar strengthening is to be fitted at the ends of poops or forecastles within ·5L amidships.

(30) INCREASE TO STRINGER AT BREAK MAY BE SPREAD OVER STRINGER WIDER THAN TABLE.

"SIMILAR STRENGTHENING..... POOPS OR FORECASTLES" MEANS SHEERSTRAKE + 50% AND STRINGER + 25%.

At the ends of short bridges these increases are to be 30 per cent and 10 per cent respectively.

In way of a long bridge the upper deck sheerstrake, stringer plate and deck plating as fitted in the wells are to extend into the bridge for a distance equal to about one-third the breadth of the ship.

(52) BRIDGE DK PLATING ONLY TO BE INCREASED AT BREAK OF BOAT DECK, WHEN BOAT DECK EXTENDS TO SHIP'S SIDE FOR A CONSIDERABLE DISTANCE.

The bridge side strakes, which are to be increased 25 per cent in thickness at the ends of the superstructure, are to be tapered as far as practicable into the bulwark plating or upper deck sheerstrake; the plating is to be efficiently stiffened at its upper edge and supported by web plates not more than 5 feet from the end bulkhead.

4. **Bulkheads at ends of Superstructures.**—The bulkheads at the ends of poops, bridges, and forecastles are to have the scantlings and arrangements given in **Table 22** and associated Notes.

5. **Deckhouses.**—(*a*) All deckhouses are to be of sufficient strength and the scantlings of the ends, sides and of the top beams are to be in accordance with the requirements of **Table 23** and associated Notes. Beams and stiffeners should, as far as possible, be fitted in line with the main framing.

(*b*) Where the length of single or two-tier deckhouses exceeds ·15L, the sectional area of the top plating is to be derived from **Table 23** and associated Notes. In all ships above 300 feet in length the exposed decks over passenger accommodation are to be completely plated.

(*c*) The sides and ends of the deckhouses are to be supported by partial bulkheads or web frames, spaced about 30 feet apart, and web frames are to be fitted, if practicable, at the sides of large openings.

Arrangements are to be made to minimise the effect of discontinuities in the deckhouse structure. All openings cut in the sides should be substantially framed and have the corners well rounded; continuous coamings are to be fitted below and above doors and similar openings. The corners of long deckhouses are to be attached to the deck by double riveted, or equivalent connections, and adequate support is to be provided below in the form of an intercostal girder and pillars or web frames.

The deckhouse sides are to be additionally stiffened in way of boats and the deck strengthened in way of the davits.

(*d*) Partial bulkheads or web frames are to be fitted in the 'tween decks below deckhouses and, where practicable, in continuation of watertight bulkheads below.

NOTICE Nº 1948. NOTE:- FOR EXPOSED CASINGS PROTECTING MACHINERY OPENINGS SEE SECTION 22 AND NOTE 11, TABLE 23.

Section 13.

RAISED QUARTER DECKS.

1. **Scantlings in way of the Raised Quarter Deck.** (*a*) The scantlings of shell, sheerstrake, stringer and deck plating are to be based on the depth D measured to the raised quarter deck.

WING BKTS BASED ON DEPTH TO UPPER DECK

(*b*) The scantlings of side frames are to be based on the depth D measured to the upper deck with h measured to the raised quarter deck.

(*c*) The scantlings of beams are to be determined using the depth D measured to the raised quarter deck.

2. **Break Bulkhead.**—The front or break bulkhead of the raised quarter deck is to have the thickness of plating required for bridge front bulkheads and is to be sufficiently stiffened.

3. **Strengthening at Break.**—(*a*) The stringer plates of the upper or bridge deck and the raised quarter deck are to overlap for three or four frame spaces at either side of the break bulkhead according to the size and proportions of the ship.

(*b*) Similarly in ships exceeding 220 feet in length the deck plating is to overlap for two or three spaces and the stringers are to extend for two or three spaces beyond the plating.

(*c*) Sufficient diaphragm plates, of the thickness of the break bulkhead, are to be fitted between the overlapped decks and connected to them and to the break bulkhead by double angles; the diaphragms are to be stiffened on their after edges and elsewhere if necessary.

(31) WHERE RQDK SCARPS INTO A POOP OF ·25 OR GREATER THE PLATING AT THE BREAK IS TO BE INCREASED IN THICKNESS

(*d*) The upper deck sheerstrake is to be increased in thickness by 40 per cent and extended for a reasonable distance abaft the break. The raised quarter deck sheerstrake is also to be increased in thickness by 30 per cent when connected to a long bridge and is to be extended into the bridge.

Section 14.

BEAMS AND DECK LONGITUDINALS.

1. **Scantlings.**—(*a*) The scantlings of deck beams at weather, cargo and accommodation decks are to be determined from **Tables 24** and **25** and associated Notes.

(*b*) The scantlings of deck longitudinals are to be determined from **Tables 26** and **27** and associated Notes.

2. **General.**—(*a*) Beams are to be fitted at every frame.

(*b*) Where hatch side coamings are more than 18 inches from the deck girder the overhanging beams are to be reinforced, or the coamings are to be made sufficiently strong to act as girders to carry the ends of the beams and the load on the hatchway.

(*c*) Beams or longitudinals at the crown of deep tanks, peak tanks and oil fuel tanks are to satisfy the requirements of **Tables 24, 25, 26** or **27** and associated Notes but are not to be less in strength than required for the stiffeners of the boundary bulkheads to those tanks. (*See* **Section 19, clause 1** (*a*) and **Section 20, clause 2** (*b*).)

(*d*) Where holes are punched in the face flange of channel or similar beams the modulus of the beams may require to be increased.

(57) IF FLANGES 3" AND 3½" COMPENSATION AS FOLLOWS:-

HOLE	5/8"	3/4"	7/8"	1"	1⅛"
INCREASE IN ¼	6%	8%	10%	12%	14%

WHERE REVERSE BARS ARE FITTED TO CHANNELS, EACH CASE TO BE CONSIDERED ON ITS MERITS, BUT TO UP TO 8% DEFICIENCY IN ¼ CAN BE ACCEPTED.

(*e*) Weather decks are to be suitably cambered.

(*f*) For strong hatch end beams and deck transverses *see* **Section 15, clauses 5** and **6.**

(*g*) For strengthening in machinery spaces *see* **Section 22, clause 3.**

3. **Beam Knees and Brackets of Deck Longitudinals.**—(*a*) The scantlings of beam knees and brackets of deck longitudinals together with their riveted attachments are to be determined from **Table 28** and associated Notes.

(*b*) Where intermediate frames in the 'tween decks are omitted the beam knees are to be attached to the shell plates by angles having the same thickness as the knees.

(*c*) In ships having more than three tiers of beams and where large areas of deck are arranged for accommodation, or where particular conditions of loading are contemplated, the requirements for beam knees will be specially considered.

(*d*) The riveted attachment of half beams to hatch side coamings and casings is given in **Table 52 (G).**

Section 15.

DECK GIRDERS AND PILLARS.

1. **General.**—Deck beams are to be supported by longitudinal deck girders in association with pillars or strong hatch end beams.

Deck longitudinals are to be supported between bulkheads by transverses pillared as necessary.

Pillars in the 'tween decks and holds are to be in the same vertical line, as far as practicable.

The scantlings are to be determined from **Tables 29, 30** and **31** and associated Notes.

2. **Special Loads.**—(*a*) Where a girder is subject to concentrated loads, such as pillars out of line, the scantlings are to be suitably increased and the pillars which support the girder are to be strengthened to bear the portion of the concentrated load which they carry.

(*b*) Where cargoes such as chilled meat are suspended from a deck which may be simultaneously loaded above, the scantlings of the girders are to be increased as required by **Table 29, Note 1** (*f*).

(*c*) Additional attachments may be required to meet particular local stresses.

3. **Longitudinal Deck Girders.**—(*a*) Girders are to be connected to the deck by angles of the same thickness as the web plate. If the span is greater than 30 feet in association with a normal height of 'tween deck, the deck connection is to be doubled for two beam spaces at each end.

(*b*) Girders of unsymmetrical section are to be supported by tripping brackets at alternate beams; if the section is symmetrical the brackets may be four frame spaces apart. Where the unsupported width of the girder flanges is 6 inches or greater the tripping brackets are to be connected to the flange. Where symmetrical sections are fitted tripping brackets are to be fitted on both sides. Intermediate beams are to be connected to the girders by lugs having the same thickness as the web plate~~; and extending to the toe of the face bar~~.

(102) THEY ARE TO EXTEND TO THE TOE OF THE FACE BAR IN WAY OF HATCHES.

The thickness of deck plating in way of the girder is to be increased where necessary to provide an effective upper flange of the girder.

(68) IF THICKNESS OF DK PLATING LESS THAN $\sqrt{\frac{\text{FACE AREA}}{180}}$ (OR $\sqrt{\frac{\text{AREA FACE}}{150}}$ FOR HATCH SIDE GIRDER) PLATING TO BE INCREASED IN THICKNESS OR DOUBLER FITTED. IF GIRDER BALANCED BY FITTING DOUBLER (OR EQUIVALENT) EQUAL TO FACE AREA, GIRDER NUMERAL CAN BE REDUCED BY 10%

(*c*) Girders are to be attached to the bulkhead by flanged brackets of the same thickness as the girder. The distance of the toe of the bracket below the deck is given in **Table 29** and the horizontal arm is to be the same as the depth below the girder. The connections of the bracket to the girder and the bulkhead are to be double riveted.

(*d*) Continuity is to be efficiently maintained over the heads of pillars, and the butts of longitudinal material in the girders are to be efficiently strapped or welded.

4. **Hatch Coamings.**—(*a*) At lower decks side coamings acting as girders and not forming part of a continuous girder are to be extended for at least two frame spaces beyond the hatch end beams by short girders below the deck.

(*b*) At weather decks deep hatch coamings which are intended to act as girders are to be extended beyond the hatchway ends in the form of brackets, the coamings below the deck being effectively connected to the hatch end beams. Where extension above the deck is not practicable the coaming below the deck is to be extended by short girders for at least two frame spaces beyond the hatch end beams.

(*c*) At the corners of all hatchways supported by hatch end beams horizontal gusset plates are to be fitted connecting the side coamings to the hatch end beams, and the vertical connections are to be double riveted or equivalent.

5. **Strong Hatch End Beams.**—(*a*) Strong hatch end beams are to be supported at the centreline and attached to the side frames by brackets equivalent to the requirements of **Table 29,** and the frames are also to be strengthened if considered necessary.

(101) TW. DK FRAMES AT STRONG HATCH END BEAMS SHOULD BE IN ACCORDANCE WITH TABLE 12. h BEING TAKEN AS DEPTH OF TWEEN DECK.

(*b*) The hatch end beams are to be connected to the deck plating by angles of the same thickness as the web plate and sufficient tripping brackets are to be fitted.

6. **Deck Transverses.**—(*a*) Transverses supporting deck longitudinals are to be attached to the frames by brackets equivalent to the requirements of **Table 29,** and tripping brackets are to be fitted as required. The transverses are to be connected to the deck by angles of the same thickness as the web plates.

(*b*) Longitudinals are to be attached to the transverses by lugs having the same thickness as the web plates and extending to the toe of the face bar.

7. **Pillars.**—(*a*) Effective arrangements are to be made to distribute the loads at the heads and heels of all pillars.

(*b*) Solid pillars may be attached to continuous runners, having scantlings given in **Table 30,** fitted under the deck beams. The runners are to be attached to each beam and to the bulkheads by angle lugs having two rivets in each flange. The heads and heels of the pillars are to have a bearing fit. At watertight and oiltight surfaces the heels are to be riveted to double angles or T bars or directly welded.

(2) DOUBLER TO BE FITTED UNDER WELDED PILLARS IN TW. DKS WHERE DECK PLATING IS THIN AND DIAMETER OF PILLAR EXCEEDS 9"

(*c*) Tubular pillars are to be attached at their heads to suitable capital plates supported by brackets, flanged where necessary, in order to transmit the load effectively. GENERALLY ·50" THICK FOR PILLARS UP TO 18" DIAM. ·60" THICK ABOVE THIS DIAM. Doubling plates are to be fitted to the inner bottom under the heels of tubular pillars, and to decks under pillars of large diameter. The pillars are to have a bearing fit and are to be attached to the capital and doubling plates by riveted angle rings or by continuous welding.

(*d*) At the heads and heels of pillars built of rolled sections the load is to be well distributed by means of longitudinal and transverse brackets.

(*e*) In double bottoms under widely spaced pillars the connections of the floors to the intercostal girders and of the floors and girders to the inner bottom are to be suitably increased. Where pillars are not directly above the intersection of plate floors and intercostal girders, partial floors and intercostals are to be fitted as necessary to support the pillars. Manholes are not to be cut in the floors and girders below the heels of pillars.

Where longitudinal framing is adopted in the double bottom equivalent stiffening under the heels of pillars is to be provided.

(*f*) In ships carrying Refrigerated Cargoes and carrying Oil Fuel in the double bottom, the connections of the hold pillars to the inner bottom, including the doubling plates, are to be welded. (*See* **Section 20, clause 11** (*a*).)

(*g*) Where the heels of pillars are carried on a tunnel, suitable arrangements are to be made to support the load.

(*h*) Where pillars are fitted under watertight flats the end attachments are to be sufficient to withstand the load due to water pressure.

(*i*) Additional pillars are to be fitted below deckhouses, windlasses, winches, capstans and elsewhere where considered necessary.

8. **Machinery Spaces.**—Arrangements for supporting the structure in machinery spaces will be specially considered.

For Centre Line and Bunker Bulkheads supporting decks, *see* **Section 18.**

For Riveting requirements *see* **Tables 31** and **52** (**G**).

Section 16.

WATERTIGHT BULKHEADS.

1. **Number and Disposition of Transverse Bulkheads.**—(*a*) All ships are to have a collision bulkhead, situated not less than ·05L from the fore end of the load waterline, an after peak bulkhead enclosing the stern tubes in a watertight compartment and a bulkhead at each end of the machinery space. WHEN A CROSS COAL BUNKER

SEE NOTICE Nº 1948.

(*b*) In ships exceeding 285 feet in length, additional bulkheads are to be fitted as follows:

Length L.		Additional Bulkheads.	Total Number.
Above.	Not exceeding.		
285	335	One, in fore hold ...	5
335	405	One, in fore hold ...	
		One, in after hold ...	6
405	470	Three	7
470	540	Four	8
540	610	Five	9

MINIMUM DISTANCE BETWEEN TWO ADJACENT BULKHEADS, TO ENABLE BOTH TO BE RECORDED IN THE REGISTER BOOK, IS TO BE TAKEN AT 10·0" + 2% OF LENGTH OF VESSEL. (L.O. 7/12/49)

(*c*) Where, in ships above 220 feet and not exceeding 285 feet in length, the machinery is aft, a watertight bulkhead is to be fitted about midway between the collision bulkhead and the bulkhead at the fore end of the machinery space.

(*d*) The Committee will be prepared to consider proposals from Owners to dispense with one or more of these bulkheads, if they interfere with the requirements of a special trade, provided that suitable structural compensation is fitted, and a notation is made in the Register Book describing the number and position of the bulkheads omitted.

2. **Height of Bulkheads.**—(*a*) The collision bulkhead is to extend to the uppermost continuous deck.

(*b*) The after peak bulkhead may terminate at the first deck above the load waterline provided this deck is made watertight to the stern or to a watertight transom floor.

(*c*) The remaining bulkheads are to extend to the uppermost continuous deck except where the draught is not greater than that permitted with a superstructure extending for the full length of the ship above the second deck, when the bulkheads may terminate at that deck provided it lies above the load water line.

In passenger ships of restricted draught the height of the bulkheads will be specially considered.

(*d*) For protection of machinery openings in 'tween decks *see* **Section 22, clause 7.**

3. **Bulkhead Plating.**—(*a*) The thickness of bulkhead plating is to be in accordance with **Table 32** and associated Notes.

(*b*) The lowest strake is to be at least 36 inches deep measured from the inner bottom, or from the keel if there is no double bottom; where an inner bottom terminates on a bulkhead the top of the lowest strake of the bulkhead is to be at least 12 inches above the inner bottom. At stokehold bulkheads in coal burning ships the lowest strake is to extend at least 24 inches above the stokehold platform.

4. **Bulkhead Stiffeners.**—(*a*) The scantlings of vertical stiffeners having bracketed or lugged end connections are to be determined from **Tables 33** and **34**, respectively, and associated Notes. The scantlings of stiffeners which are bracketed at one end and lugged at the other may be aken as a mean between those required by **Tables 33** and **34.**

The scantlings for stiffeners in Tugs are given in **Table 35.**

(*b*) The Tables apply to stiffeners spaced 24 inches apart at collision bulkheads and 30 inches apart at other watertight bulkheads not forming boundaries of tanks. Scantlings are to be corrected as required by the Notes for departures from Table spacing.

(*c*) Where bulkhead stiffeners are cut in way of watertight doors in the lower part of a bulkhead the opening is to be suitably framed, and a tapered web plate, stiffened on its edge, is to be fitted on each side of the door from the base of the bulkhead to well above the opening.

Where stiffeners are not cut but the spacing between the stiffeners is increased on account of watertight doors, as in 'tween deck bulkheads, the stiffeners at the sides of the doorways are to be increased in depth and strength so that the efficiency is at least equal to that of the unpierced bulkhead, without taking the stiffness of the door frame into consideration.

(*d*) Bulkheads are to be suitably strengthened if necessary at the ends of deck girders and where subjected to concentrated loads.

(69) END BRACKETS FOR TOE WELDED ANGLES TO BE 2½ TIMES TABULAR RULE B.A. STIFFNR.

5. **End Attachments of Stiffeners.**—(*a*) End brackets for stiffeners derived from **Table 33** are to have dimensions, measured from the heel of the boundary angle to the toes of the bracket, equal to two and a half times the depth of the stiffener. The thickness of the brackets and the number of rivets required are given in **Table 36.**

The bracket or its connecting angle at the lower end of each stiffener is to extend to the floor adjacent to the bulkhead.

At each deck level which forms the top of a system of stiffeners plating is to be provided of a character which will ensure rigidity, and the attachments of the upper brackets on the hold stiffeners to this plating re to extend over a beam space.

Where the inner bottom is framed longitudinally the stiffeners of the bulkhead should be arranged, if practicable over the longitudinals.

(*b*) End lugs for stiffeners derived from **Table 34** are to be of the same thickness as the boundary angles and are to be riveted as required by **Table 36.**

DREDGERS:- END BHDS OF HOPPERS HAVE BEEN TAKEN AS W.T. BHDS, WITH STIFFNRS SPACED 24" INSTEAD OF 30" (PER J.R.C)
IN SIMONS Nº 795, STIFFNRS TAKEN AT 75% OF TANK STIFFNRS.

6. **Boundary Connections.**—Angles connecting bulkheads to shell, inner bottom and deck plating are to be ·10 inch thicker than the Table thickness of the bulkhead plating to which they are attached.

7. **Watertight Recesses and Flats.**—(*a*) Watertight recesses in bulkheads are to be framed and stiffened so as to provide strength and stiffness equivalent to the requirements for watertight bulkheads.

(*b*) Horizontal plating is to be ·04 inch thicker than required by **Table 32** for watertight bulkheads at corresponding levels. The strength and stiffness of beams are to be equivalent to the requirements of **Table 33** if cut and bracketed or continuous.

The thickness of plating and scantlings of beams are not to be less than required by **Sections 11** and **14.**

8. **Longitudinal Bulkheads.**—Watertight longitudinal bulkheads are to be equal in strength and stiffness to the requirements for transverse bulkheads.

9. **Chain Lockers.**—Chain lockers fitted abaft the collision bulkhead are to be caulked and the space is to be efficiently drained.

10. **Riveting.**—Requirements for riveting are given in **Table 52 (G).**

11. **Welded Stiffeners.**—The scantlings of welded stiffeners will be considered in accordance with **Note 3** to **Tables 33, 34, 35** and **36.**

12. **Watertight Doors.**—(*a*) Watertight doors are to be efficiently constructed and fitted, tried under working conditions and hose tested in place.

Provision should be made to ensure that coal will not impede the satisfactory operation of bunker doors.

(*b*) Watertight doors are to be capable of being quickly closed from an accessible position above the bulkhead deck, and are to have an index at the operating position showing whether the door is open or closed. Hand gear is to have an all-round motion. The lead of shafting is to be as direct as possible and the screw is to work in a gunmetal nut.

(*c*) Hinged watertight doors of approved pattern may be fitted in 'tween decks in approved positions. The hinges of these doors are to be fitted with gunmetal pins.

13. **Caulking and Testing.**—Watertight bulkheads, including recesses and flats, are to be caulked and hose tested on completion. At watertight flats the side frames if continuous are to be suitably collared, alternatively they may be cut and bracketed or otherwise effectively connected to the flat.

Peak bulkheads not forming boundaries of tanks are to be tested by filling the peaks with water to the level of the load water line.

For Deep Tanks, Peak Tanks and Oil Fuel Bunkers *see* **Sections 19** and **20.**

For Watertight Tunnels *see* **Section 17.**

Section 17.

WATERTIGHT TUNNELS.

1. **Tunnels.**—Where machinery is amidships the shafting is to be enclosed in a watertight tunnel large enough to permit of proper examination and repair of the shafting. A watertight door is to be provided at the forward end of the tunnel. Pipe tunnels are to have dimensions adequate for reasonable access.

2. **Plating.**—(*a*) The thickness of plating on flat sides and curved tops of tunnels is to be determined from **Table 37** and associated Notes.

If the top of the tunnel is flat the plating is to be as required by **Section 16, clause 7,** for horizontal flats of watertight bulkheads.

(*b*) Under hatchways the top plating is to be increased by ·10 inch, unless covered with wood not less than 2 inches in thickness which is to be secured without through fastenings in the plating.

3. **Stiffeners and End Attachments.**—The scantlings of stiffeners are to be determined from **Table 38** and associated Notes.

For flat tunnel tops the scantlings of stiffeners are not to be less than required by **Section 16, clause 7** for flats of watertight bulkheads.

The stiffeners are to overlap and be connected to the tunnel base angle. Angle stiffeners 6 inches in depth and all bulb angle stiffeners are to be attached to the inner bottom by lugs riveted as required by **Table 36.** Where welded construction is adopted equivalent arrangements are to be made.

4. **Boundary Angles.**—The thickness of all boundary angles is to be ·10 inch greater than the Table thickness of curved top plating given in **Table 37.**

5. Recesses.—The scantlings of plating and stiffeners for thrust and other recesses are to be determined as required by **Section 16, clause 7,** for watertight bulkheads.

6. Tunnels in Deep Tanks.—When tunnels and recesses form boundaries of deep tanks the requirements of **Section 19** or **20** are also to be complied with.

7. Local Strengthening.—Additional strengthening is to be fitted under the heels of pillars, hatch end supports or masts stepped on the tunnel. The strength of bulkheads in way of watertight doors is to be maintained as required by **Section 16, clause 4** (*c*).

8. Ventilators.—Tunnel ventilators are to have scantlings suitable for the pressure to which they may be subjected and are to be made watertight.

9. Riveting, Caulking and Testing.—Riveting and caulking are to be as required by **Section 16, clauses 10 & 13** for watertight bulkheads.

Tunnels are to be hose tested on completion.

Section 18.

NON-WATERTIGHT BULKHEADS.

1. **Centreline Bulkheads.**—(*a*) The thickness of bulkhead plating in ships exceeding 150 feet in length is to be ·30 inch in holds and ·26 inch in 'tween decks.

(*b*) Riveted connections of bulkheads to the decks and inner bottom are to be by single angles ·36 inch in thickness, but the attachments to the inner bottom are to be double riveted for two frame spaces at the ends of the hatchways; welded connections are to be of equivalent strength.

(*c*) The scantlings of stiffeners are to be determined from **Table 39** and associated Notes. The stiffeners may be spaced two frame spaces apart provided the frame spacing does not exceed 30 inches.

(*d*) Hold stiffeners are to be attached to the inner bottom by double riveted lugs or welded at their lower ends. Stiffeners at the ends of hatchways, both in holds and 'tween decks, are to have flanged brackets at top and bottom, or equivalent arrangements. Deck beams are to be connected to the stiffeners or plating of the bulkhead.

2. **Coal Bunker Bulkheads.**—(*a*) The thickness of plating is to be as required by **clause 1** (*a*) above, but the thickness of the lowest strake is to be ·36 inch; this strake is to extend at least 24 inches above the stokehold platform. Boundary angles are to be ·36 inch in thickness at the top and sides and ·40 inches at the bottom.

(*b*) The scantlings of stiffeners of longitudinal bulkheads which support the deck are to be as required by **clause 1** (*c*) above.

(*c*) The scantlings of stiffeners of transverse bulkheads and of longitudinal bulkheads not supporting the deck are to be as required by **Table 39, Note 4.**

(*d*) At sloping bunker casings the scantlings of stiffeners are to be suitably increased or the stiffeners are to be additionally supported by angle stays from the deck beams.

FOR NON-WATERTIGHT BHDS AT AFTER ENDS OF CROSS BUNKERS SEE NOTICE Nº 1948.

Section 19. SEE SEC. 16. CL 1 (a)

DEEP TANKS AND PEAK TANKS.

1. **Bulkheads.**—(*a*) The scantlings of plating and stiffeners of boundary bulkheads are to be determined from **Tables 32** and **40,** respectively, and associated Notes. The plating is not to be less in thickness than ·30 inch in ships exceeding 150 feet in length. Stiffeners are to have bracketed attachments as required by **Section 16, clause 5** (*a*).

(*b*) Boundary angles are to be ·10 inch thicker than the Table thickness of the bulkhead plating to which they are attached.

(*c*) The maximum head to which the tank will be subjected is to be shown on the plans submitted for approval,

(*d*) For tanks which exceed 30 feet in length the scantlings and arrangements will be specially considered.

ASSUMED TO APPLY TO UNSHEATHED DK AS FORMERLY

21	·30
22	·307
23	·313
24	·32
25	·327
26	·333
27	·34
28	·347
29	·353
30	·36
31	·367
32	·373
33	·38
34	·387
35	·393
36	·40

2. **Decks.**—(*a*) The thickness of plating of a deck forming the crown of a tank is to be ·04 inch greater than that which would be required by **Table 32** for plating at the same depth, corrected, if necessary, for spacing, but is not to be less than ·32 inch with beams or longitudinals spaced 24 inches apart and ·40 inch where the spacing is 36 inches, with proportionate thickness for intermediate spacing; the plating is also to satisfy the requirements of **Section 11.**

(*b*) Beams are to be equivalent in strength to the stiffeners of boundary bulkheads, but are also to satisfy the requirements of **Section 14.**

(*c*) Beams in deep tanks are to be supported by quarter girders, the scantlings of which are to be determined from **Table 41** and associated Notes but are not to be less than would be required by **Section 15.**

(*d*) Pillars supporting the deck girders are to satisfy the requirements of **Section 15, clause 7.**

SEE ALSO DECISION (111) AT FOOT OF PAGE.

NOT IN TUNNEL SIDE TANKS UP TO ABOUT 10'-0" IN DEPTH.

3. **Side Frames.**—The modulus of side frames in deep tanks is to be increased by 15 per cent beyond the requirements of **Section 6.**

4. **Tunnels and Recesses.**—The scantlings and arrangements of tunnels, horizontal and longitudinal steps and recesses generally are to be equivalent to the requirements for boundary bulkheads.

5. **Washplates.**—Washplates are to be fitted at the centre line in peak tanks, and in deep tanks when the breadth of the tank exceeds 30 feet. Washplates should be as deep as practicable and sufficiently stiffened to ensure lateral rigidity. Where a complete centreline division is fitted in deep tanks the arrangements are to be as required by **Section 20, clause 7.**

6. **Ventilators.**—Ventilators from deep tanks passing through a 'tween deck are to be strong enough to withstand the pressure to which they may be subjected and they are to be made watertight.

7. **Riveted Connections.**—Riveted connections are to be in accordance with the requirements of **Table 52 (G).**

8. **Testing.**—Tanks are to be tested by a head of water equal to the maximum to which the tank may be subjected, but not less than 8 feet above the crown of the tanks where the depth D (**Section 2, clause 3** (*b*)) exceeds 16 feet, reduced to 3 feet where D is 10 feet or less.

9. **General.**—(*a*) When boundary bulkheads of tanks form part of the watertight subdivision of the ship the requirements of **Section 16** are also to be satisfied.

(*b*) Tanks intended to carry oil fuel or liquid cargoes are to comply with the requirements of **Section 20** or **21.**

For Air and Sounding Pipes *see* **Section 24.**

For Pumping and Piping arrangements *see* **Rules for Pumping and Piping.**

Section 20.

DEEP TANKS AND DOUBLE BOTTOM TANKS CARRYING OIL FUEL FOR SHIP'S USE.

1. **Flash Point.**—(*a*) The following requirements apply to the construction of compartments for the carriage, for ship's use, of oil fuel the close test flash point of which, as determined by a standard type of flash point apparatus, is above 150° F.

(*b*) When the requirements of the Rules have been complied with a record will be made in the Register Book, except for Motor Ships, as follows: "Fitted for oil fuel (date) F.P. above 150° F."

2. **Boundary Bulkheads.**(*a*)—The thickness of plating is to be determined from **Table 32** and associated Notes; the plating is not to be less than ·30 inch in thickness in ships exceeding 150 feet in length.

(*b*) The scantlings of stiffeners are to be determined from **Table 40** and associated Notes. The ends of the stiffeners are to be attached by brackets in accordance with **Section 16, clause 5** (*a*). The stiffeners are to be supported, if necessary, by horizontal girders as required by **clause 3** below.

(*c*) For tanks which exceed 30 feet in length the scantlings and arrangements will be specially considered.

3. **Horizontal Girders.**—(*a*) Bulkhead stiffeners and side frames are to be supported by horizontal girders, spaced not more than 10 feet apart, having scantlings determined from **Table 41** and associated Notes.

(*b*) The girders on bulkheads and ship's sides are to form a continuous line of support. They are to be connected at their ends by flanged brackets, having the same thickness as the web plate of the thicker girder and a length of arm, measured from the point of the bracket to the edge of the girder, equal to the width of the wider girder. If the bracket terminates on a bulkhead the length of the arms is to be equal to the width of the girder. All girders and brackets are to be double riveted or to have equivalent welded connections and the ends of the brackets are to be adequately supported.

(*c*) Riveted connections of girder plates to the bulkheads or shell plating are to be double for about twice the width of the girder at each end and may be single elsewhere.

(*d*) The girders are to be supported by tripping bracket at the toes of the end brackets and elsewhere at every third stiffener or frame. Stiffeners or frames intermediate between these brackets are to be effectively connected to the girders.

(*e*) For tanks which exceed 30 feet in length the scantlings and arrangements will be specially considered.

4. **Side Frames.**—The scantlings of side frames are to be as required by **Section 6,** the framing depth h being measured without reference to the horizontal side girders, but the modulus may be reduced by 10 per cent where one girder is fitted or by 20 per cent where there are two girders. Where a horizontal girder is not required the modulus of the framing is to be increased in accordance with **Section 19, clause 3.**

(111) WHERE DEEP TANKS ARE FITTED FORWARD THE FRAMING IS TO BE INCREASED IN ACCORDANCE WITH SECTION 9, PARA 3, OR SECTION 20, PARA 4, WHICHEVER IS THE GREATER.
WHERE GIRDERS, FACTOR = 1·20 × ·80 OR ·90.

5. **Decks.**—(*a*) The scantlings of decks forming the crowns of oil fuel tanks are to comply with the requirements for Deep Tanks given in **Section 19, clause 2.**

(*b*) Where a steel deck abuts on an oil bunker bulkhead the deck plating is to be attached to the bulkhead either by double angles, single riveted, by a T bar, or by an equivalent welded connection. If the deck acts as a girder supporting the bulkhead stiffeners the panel of deck plating adjoining the bulkhead may require to be stiffened for this purpose.

6. **Tunnels and Recesses.**—The scantlings and arrangements of tunnels, horizontal and longitudinal steps, and recesses generally, are to be equivalent to the requirements for boundary bulkheads.

7. **Centre Line Bulkheads.**—(*a*) Deep tanks which extend from side to side of the ship are to have a centre line bulkhead and quarter girders.

(*b*) Centre line bulkheads may be intact or perforated as desired. If intact, the scantlings and arrangements are to be as required for boundary bulkheads by **Clause 2** above.

If perforated, the modulus of the stiffeners may be 50 per cent of that required for boundary bulkheads by **Section 19,** using H measured to the crown of the tank. The stiffeners are to be bracketed at top and bottom. The area of perforations is not to be less than 5 per cent nor more than 10 per cent of the total area of the bulkhead.

When brackets from horizontal girders on the boundary bulkheads abut on the centre line bulkhead a light intercostal stringer is to be fitted at that level for the full length of the tank, or equivalent arrangements are to be provided.

8. **Ventilators.**—Ventilators from deep tanks, passing through a 'tween deck, are to be strong enough to withstand the pressure to which they may be subjected and they are to be made oiltight.

9. **Watertight Sub-division.**—When the bulkheads of oil fuel bunkers form part of the watertight subdivision of the ship, they are also to comply with the requirements of **Section 16.**

10. **Double Bottom Tanks.**—(*a*) Holes are not to be cut in the centre girder except in the forward and after tanks, and elsewhere where tanks are narrow due to sub-division. The centre girder need not be caulked or tested.

(*b*) The inner bottom plating in cargo holds where there is no ceiling is not to be less in thickness than ·34 inch when the spacing of frames or longitudinals is 24 inches and ·40 inch when the spacing is 30 inches, with proportionate thicknesses for intermediate spacing.

Seams and end laps of inner bottom plating in the engine and boiler spaces, and in the holds where ceiling is not fitted over the whole inner bottom are to be at least double riveted.

11. **Special Requirements for Refrigerated Ships.**—(*a*) Where the hold above a double bottom tank carrying oil fuel is used for refrigerated cargo the tank side brackets and floor plates are to be attached to the margin plate by T bars, or by welding, and gussets are to be welded to the margin plate. The connections of hold pillars, including heel doubling plates, also of the floors and intercostal plates under the pillars to the inner bottom are to be welded. The attachments of manhole covers are not to pass through the inner bottom plating.

(*b*) For the requirements for protection of oiltight bulkheads, decks and inner bottom in way of refrigerated holds *see* **Section 3, clause 5** of **Rules for Refrigerating Machinery and Appliances of Ships.**

12. **Protection and Drainage.**—(*a*) Compartments carrying oil are to be separated by cofferdams from those carrying fresh water; oil fuel compartments are to be similarly separated from those carrying vegetable oil. Cofferdams are to be suitably ventilated.

(*b*) Sparring or lining is to be fitted on the bulkheads in holds to prevent leakage of oil coming into contact with the cargo. Gutterways are to be arranged at the foot of these bulkheads to ensure that leakage shall have free drainage to the wells or limbers. Gutterways are also to be fitted in boiler spaces.

(*c*) Where a bulkhead including its boundary connections is wholly welded the requirements of (*b*) above may be dispensed with, except that a gutterway is to be fitted in the boiler room.

(*d*) Ceiling on the inner bottom, if fitted, is to be laid on battens not less than half an inch in thickness. Battens are to be laid so as to permit the drainage of oil to the bilges or wells.

(*e*) Drip trays or gutterways with suitable draining arrangements are to be provided for all tanks which do not form part of the ship's structure, at pumps, valves and

24 ·34
25 ·35
26 ·36
27 ·37
28 ·38
29 ·39
30 ·40
NO NEED TO EXCEED ·40

(85) WHERE BULKHEAD WHOLLY WELDED EXCEPT FOR BOUNDARY, LOCAL SPARRING SUFFICIENT & GUTTERWAY OMITTED IF BILGE PROVIDED.

No NEED TO MAKE ANY RESERVATION REGARDING HEAD, ONUS BEING LEFT ON OWNERS. BURNTISLAND 337.

elsewhere where there is a possibility of leakage. Drip trays are also to be fitted under oiltight decks, except if these are completely welded when the drip trays need only be fitted over the boilers.

(*f*) If cargo or coal is carried in a compartment adjacent to an oil fuel settling tank which may be heated, the compartment side of the bulkhead or deck is to be insulated.

13. **Riveted Connections.**—Riveted connections are to be in accordance with the requirements of **Table 52 (G)**.

14. **Testing.**—All oil tanks are to be tested by a head of water equal to the maximum to which the tank may be subjected but not less than 8 feet above the crown of the tank where the depth D (**Section 2, clause 3** (*b*)) exceeds 16 feet, reduced to 3 feet where D is 10 feet or less. The attachment of fittings to oiltight surfaces should be completed before the tanks are tested.

15. **Workmanship.**—The workmanship throughout is to be of the highest character and is to be submitted to close inspection. (*See* **Section 32.**)

For air and sounding pipes and the arrangements and requirements for the use of oil fuel, *see* **Rules for Pumping and Piping.**

Section 21.

DEEP TANKS AND PEAK TANKS CARRYING OIL AS CARGO.

1. **Oil Fuel.**—(*a*) Oil fuel having a flash point above 150° F. may be carried as cargo in deep tanks or peak tanks provided the scantlings and arrangements of the tanks are in accordance with the requirements of **Section 20** for oil fuel bunkers, except that the riveting may be as required for deep tanks by **Table 52 (G)** and a wash plate may be fitted in place of the complete centre line bulkhead; if, however, the tanks are intended to be partially filled only, the requirements of **Section 20** are to be complied with in all respects.

(*b*) When these requirements have been carried out a notation will be made in the Register Book as follows: "Carrying Oil, F.P. above 150° F. in deep and (or) peak tanks".

2. **Vegetable and Similar Oils.**—(*a*) Vegetable oil, or similar oils, may be carried in deep or peak tanks constructed in accordance with the requirements of **Section 19** for ballast tanks, with the addition of a centre line bulkhead as required by **Section 20, clause 7**, provided that the ventilation, drainage and control generally are as required for oil fuel bunkers.

(*b*) Tanks are to be designed and constructed with a view to their being cleaned with reasonable facility.

(*c*) Deep or peak tanks carrying vegetable or similar oils are to be separated from those carrying oil fuel or fresh water by a cofferdam. PROVIDED ARRGTS ARE MADE TO PREVENT THE CROWN OF D.B

(*d*) When these requirements have been complied with BEING SUBJECTED a notation will be made in the Register Book as follows:— TO PRESSURE FR

"Carrying Vegetable Oil in deep and (or) peak tanks." THE O.F. IN THE D.

(*e*) Vegetable oil may also be carried in tanks complying VEGETABLE OIL M with the requirements of **Clause 1**, above, and if desired BE CARRIED IN TH the notation may be as follows:— DEEP TANK IMMED

"Carrying Oil F.P. above 150° F. or vegetable oil, in ABOVE (L.D. 24/6 deep and (or) peak tanks."

(*f*) Where tanks are intended for other liquid cargoes of a special nature the scantlings and arrangements will be considered in relation to the density and nature of the cargo and an appropriate notation will be made in the Register Book.

3. **Loading Certificates.**—When a loading certificate is requested, before a cargo of oil is loaded the tank should be tested under pressure and examined for cleanness to ensure that it is in a proper condition to receive the oil cargo.

In special circumstances the Committee will be prepared, with the consent of all interested parties, to consider alternative arrangements in respect of the testing of these tanks.

For requirements for protection of oil tight bulkheads and decks in way of refrigerated holds *see* **Section 3, clause 5** of **Rules for Refrigerating Machinery and Appliances of Ships.**

Section 22.

MACHINERY SPACES.

1. **Engine Seatings.**—(*a*) Built up engine seatings are to be of ample scantlings and efficiently supported by brackets both longitudinally and transversely. The transverse brackets should be fitted over the floors and, as far as practicable, the longitudinal girders in the bottom are to be under those in the seating.

(*b*) If engines are bolted directly to the inner bottom the thickness of the plating under the engines is to be suitably increased.

(*c*) In ships having a single bottom in the engine space, the floors are to be increased in depth (*see* **Section 4, clause 1** (*c*)) and the engines are to be seated on plating of substantial thickness.

(*d*) Additional full depth fore and aft girders are to be fitted under the engines and thrust block seatings. (*See* **Section 4, clause 4** (*e*), and **Section 5, clause 3** (*b*) and (*c*).)

(*e*) If engines are of relatively high power the strength of the structure and attachments of the seating are to be increased, special consideration being given to the power and type of engines and the relation of height of the engines to the width of the bedplate; particulars are to be submitted.

2. **Boiler Bearers.**—Boiler bearers are to be of substantial construction and efficiently supported by brackets. (*See also* **Section 4, clause 2** (*b*), and **Section 5, clause 4** (*a*).)

3. **Additional Strengthening in Machinery Space.**—Additional transverse strengthening is to be provided by means of web frames and strong beams, with suitable pillaring or other arrangements.

4. **Clearance between Bulkheads and Boiler.**—(*a*) Bunker and hold bulkheads are to be kept well clear of boilers and uptakes and sufficient space is to be allowed all round boilers for proper access.

(*b*) Decks, or the tops of recesses, are not to be less than 4 feet clear of the top of the boiler. Uptakes and flat surfaces of boilers are not to be less than 18 inches, and the cylindrical shells of boilers not less than 9 inches, from coal bunker and hold bulkheads.

5. **Protection of Decks under Donkey Boilers.**—Decks under donkey boilers are to be increased ·10 inch in thickness and protected under coal-fired boilers by not less than 2 inches of firebrick or cement. These requirements are to extend to any part of the deck on to which fires from the donkey boiler may be drawn.

6. **Exposed Casings Protecting Machinery Openings.**—(*a*) Engine and boiler openings on weather decks are to be protected by casings of adequate height having scantlings determined from Table 42 and associated Notes. The tops of casings are to be suitably plated and stiffened.

(*b*) The deck openings should not be larger than necessary and suitable cross tie arrangements are to be provided.

(*c*) On the uppermost continuous deck of ships in which the draught is the maximum permitted for the dimensions of the ship with the depth D measured to that deck, and on raised quarter decks the doors in exposed casings are to be of steel. All doors are to be strongly constructed and capable of being closed and secured from both sides.

The sills of exposed doorways on the uppermost continuous deck, where the draught is as defined above, are to be 24 inches in height above the upper surface of the deck; the sills of exposed doorways on raised quarter decks are to be 18 inches and those on other superstructure decks, including those extending for the full length of the ship, 15 inches in height.

7. **Protected Casings.**—The plating is to be not less than ·26 inch in cargo spaces and ·20 inch in accommodation spaces in superstructures; stiffeners are to be $3 \times 2\frac{1}{2} \times \cdot 26$ inch angles spaced 30 inches apart. Where trunked casings form boundaries of coal bunkers they are to comply with the requirements of **Section 18, clause 2.**

8. **Skylights and Gratings.**—Engine room skylights are to be substantially constructed and are to be securely connected to the coamings. Gratings over stokehold openings are to be protected by hinged plate covers, which are to be watertight if the level of the openings is less than 2 feet above the top of the hatch coamings required by **Section 23, clause 1.**

For scantlings of single bottoms in machinery space, *see* **Section 4, clause 5.**

For scantlings of double bottoms in machinery space, *see* **Section 5, clause 10.**

For frames in boiler room, *see* **Section 6, clause 6** (*b*).

Section 23.

HATCHWAYS AND DECK OPENINGS.

1. **Height of Coamings.**—The minimum height of steel coamings above the upper surface of decks is to be as follows:—

(*a*) On the weather portions of the uppermost continuous deck where the draught is the maximum permitted for the dimensions of the ship with the depth D measured to that deck ... ... 24 inches.

(*b*) On the weather portions of superstructure decks, including superstructures extending for the full length of the ship, for the forward ·25L ... ... 24 inches. for the remainder and on raised quarter decks 18 inches.

SLOPING HATCH SIDE COAMINGS
AILSA 475
GRANGEMOUTH 498.
LEWIS 226.

(*c*) On decks inside superstructures where the openings in the end bulkheads have no means of closing 18 inches

(*d*) On decks inside superstructures where the openings in the end bulkheads are closed by strong hinged wood doors, wood shifting boards fitted in channels or portable plates secured by hook bolts ... ... 9 inches.

(*e*) Hatchways on other decks and in positions not detailed above are to be suitably framed.

100' ·36"
110' ·368
120' ·376
130' ·384
140' ·392
150' ·40
160' ·408
170' ·416
180' ·424
190' ·432
200' ·44

2. **Construction of Coamings.**—(*a*) At hatchways exposed to the weather the thickness of the side and end coaming plates is to be ·44 inch where the length L is 200 feet or greater and ·36 inch where L does not exceed 100 feet, with intermediate values obtained by interpolation. Coamings are to be stiffened on their upper edges by a substantial moulding. At hatchways below the uppermost continuous deck or within an intact superstructure the coamings are not to be less than ·40 inch in thickness.

(*b*) Angles connecting the coamings to the deck and the corner angles connecting the side and end coamings are to be of the same thickness as the coaming plates. Coaming angles are to extend ½ inch above the wood deck.

(*c*) Side coamings of all hatchways are to extend at least to the lower edge of the beams which are to be attached to the coamings as required by **Table 52** (**G**).

(*d*) Hatchway side and end coamings which are 24 inches or more in height are to be stiffened by a horizontal bulb angle, or equivalent, fitted near the upper edge of the coaming; in ships 250 feet or more in length the bulb angles are not to be less than 7 inches in depth. Additional support is to be afforded by fitting brackets or stays from the bulb angle to the deck at intervals of not more than 10 feet.

(*e*) The scantlings and arrangements of coamings more than 36 inches in height and of coamings acting as girders will be specially considered. (*See also* **Section 14, clause 2** (*b*), and **Section 15, clauses 4** and **5.**)

(*f*) Coamings are to be made watertight above the deck and coaming angles are to be suitably turned or the coamings welded.

3. **Hatchway Beams and Carriers.**—(*a*) Scantlings of hatchway beams are to be determined from **Table 43** and associated Notes.

(*b*) Web plate beams are to be stiffened at their upper and lower edges by double angles or welded face plates, but when bulb plates are fitted this stiffening is required at the upper edge only. The upper angles or face plates are to extend to the extreme ends of the beams.

(*c*) The ends of the web plates are to be flushed up on each side by doubling plates of the same thickness as the mounting angles and at least 7 inches wide. In welded hatchway beams, equivalent arrangements for stiffening the ends of the web plates are to be adopted.

(*d*) At beams which carry the ends of wood hatch covers the web plate is to extend well above the top of the upper angles or face plate of the hatch beams. The bearing surface for hatch covers is not to be less than 2½ inches. (*See also* **clause 4** (*d*).)

(*e*) Hatchway beams are to be supported at their ends by carriers, sockets or other suitable arrangements, having a minimum bearing surface of 3 inches. Carriers formed of angles are not to be less than ·50 inch thick and one angle is to be extended down to the level of the deck. If the carriers are of a form which will not permit of extension to the deck level the coaming plate is to be increased in thickness by 12½ per cent. or equivalent strengthening provided.

(*f*) The bottoms of all carriers are to be of solid construction.

(*g*) Sliding hatchway beams are to be provided with an efficient device for locking them in their normal positions and with means for preventing their lifting or slewing when being moved along the coamings.

4'9"	2·229	5'9"	2·811
10	2·278	10	2·86
11	2·326	11	2·90
5'0"	2·375	6'0	2·95
1	2·424	1	3·00
2	2·477	2	3·05
3	2·521	3	3·10
4	2·569	4	3·15
5	2·618	5	3·20
6	2·666	6	3·25
7	2·715	7	3·29
8	2·763	8	3·34

4. **Hatch Covers.**—(*a*) Hatch covers are to be fitted to the hatchways of all decks, except that at hatchways on decks as defined in **clause 1** (*e*) the hatch covers may be dispensed with if desired by the Owners.

(*b*) The finished thickness of wood hatch covers at hatchways on weather decks, and in 'tween decks of normal height, is to be 2⅜ inches for an unsupported span of 5 feet, and 3¼ inches for 6 feet 6 inches; the thicknesses for intermediate spans are to be in proportion.

When the 'tween deck height in cargo spaces exceeds 8 feet 6 inches the thickness of the covers is to be increased at the rate of 5 per cent per foot excess in 'tween deck height.

(*c*) The ends of all wood hatch covers are to be protected by encircling galvanised steel bands, about 2½ inches wide and ⅛ inch thick, efficiently secured.

(*d*) Hatch rests shall be of the same thickness as the mounting angles given in **Table 43** (**A** & **B**) and shall provide at least 2½ inches bearing surface for the hatch covers; they shall be bevelled if required to suit the slope of the hatches.

(*e*) If steel hatch covers are adopted particulars of the scantlings and securing arrangements are to be submitted.

5. Tarpaulins and Securing Arrangements.—(*a*) Tarpaulins in good condition are to be provided for all hatchways requiring by **clause 1** coamings 9 inches or more in height; not less than two tarpaulins are to be provided for all hatchways in exposed positions.

(*b*) Tarpaulins are to be free from jute, thoroughly waterproofed and of ample strength. The minimum weight of the material before treatment shall be 19 ozs. per square yard if the material is to be tarred, 18 ozs. if to be chemically dressed or 16 ozs. if to be dressed with black oil.

A certificate to the above effect is to be supplied by the Makers of the tarpaulins.

(*c*) Cleats are to be fitted at all hatchways requiring tarpaulins, spaced not more than 2 feet from centre to centre, the end cleats being arranged not more than 6 inches from the hatchway corners. Cleats are to be of an approved pattern at least $2\frac{1}{2}$ inches wide, with edges so rounded as to minimise the cutting of the wedges. The thickness should not be less than $\frac{3}{8}$ inch for angle cleats and $\frac{7}{16}$ inch for smithed cleats which should be stiffened by pressing out the centre to form a web extending to the bottom of the palm. Drop forgings should be of equivalent strength. Cleats should be set so as to fit the taper of the wedges.

(*d*) Battens and wedges are to be efficient and in good condition. Wedges are to be of tough wood, generally not less than 8 inches in length and 2 inches in width. They should be cut on a standard taper of one in six and should not be less than $\frac{1}{2}$ inch in thickness at the point.

(*e*) Where coamings are required to be 24 inches in height, steel bars or other equivalent means are to be provided for efficiently and independently securing each section of hatchway covers after the tarpaulins are battened down. Where hatchway covers extend over intermediate supports, steel bars or their equivalent are to be fitted at each end of each section of covers. At all other hatchways in exposed positions on weather decks, ring bolts or other fittings for lashings are to be provided.

6. Bunker, Access and Trimming Hatchways.—The construction and the closing and securing arrangements of bunker, access and trimming hatchways are to comply with the requirements of **clauses 1** to **5** so far as applicable.

7. Flush Bunker Scuttles.—(*a*) Flush bunker scuttles may be fitted on superstructure decks, including raised quarter decks.

(*b*) The scuttles are to be substantially constructed with screw or bayonet joints. If the scuttles are not hinged the covers are to be permanently attached by a chain.

8. Trunked Hatchways. — When hatchways are trunked through one or more 'tween decks, and hatchway beams and covers are dispensed with at the intermediate decks, the hatchway beams, coamings and covers immediately below the trunk are to be adequately strengthened; plans are to be submitted for approval.

9. Companionways. — (*a*) Companions on exposed decks are to be of steel effectively secured to the deck. The height of the doorway sill is to be as required for hatchway coamings in the same position.

(*b*) Within the forward ·25L the doors are to be of steel and elsewhere may be of hard wood not less than 2 inches in thickness. The doors are to be capable of being operated and secured from both sides.

Section 24.

VENTILATORS, AIR PIPES AND SOUNDING PIPES.

1. Ventilation, General.—Ventilators are to be sufficient in number and size to provide adequate ventilation for all spaces.

Where mechanical ventilation is adopted plans showing the construction of the weather deck fittings are to be submitted for approval.

2. Ventilator Coamings.—(*a*) The minimum heights of ventilator coamings above the upper surface of decks exposed to the weather are to be as follows:—

On the uppermost continuous deck where the draught is the maximum permitted for the dimensions of the ship with the depth D measured to that deck ... ... 36 inches.

On superstructure decks, including superstructures extending for the full length of the ship, for the forward ·25L ... ... 36 inches.

for the remainder and on raised quarter decks ... ... 30 inches.

Ventilator coamings of a greater height than 36 inches are to be specially supported and secured.

(*b*) The scantlings of the coamings and their attachment, if riveted, to the deck plating are to be in accordance with the following Table :—

Internal Diameter of Ventilator Coamings.	Coaming Plate.	Deck Angle.	Rivets at 4 dia. apart C^r to C^r
Inches.	Inches.	Inches.	Dia.-Inches.
6 and not exceeding 8	·30	3 ×3 ×·34	$\frac{3}{4}$
Above 8 „ 11	·32	3 ×3 ×·36	$\frac{3}{4}$
„ 11 „ 13	·34	$3\frac{1}{2}\times3\frac{1}{2}\times\cdot38$	$\frac{3}{4}$
„ 13 „ 15	·36	$3\frac{1}{2}\times3\frac{1}{2}\times\cdot40$	$\frac{3}{4}$
„ 15 „ 17	·38	$3\frac{1}{2}\times3\frac{1}{2}\times\cdot42$	$\frac{7}{8}$
„ 17	·40	$3\frac{1}{2}\times3\frac{1}{2}\times\cdot44$	$\frac{7}{8}$

(*c*) When the deck is sheathed with wood the vertical flange of the coaming angles is to extend half an inch above the wood sheathing.

(*d*) The deck plating in way of ventilator coamings is to be efficiently stiffened between the beams or longitudinals.

3. **Covers.**—All ventilator coamings are to be provided with strong plugs and canvas covers, or equally efficient appliances, for closing the openings when the cowls are unshipped.

4. **Minor Ventilators.**—Mushroom and gooseneck ventilators are to be strongly constructed and efficiently secured to the deck plating.

5. **Air and Sounding Pipes.**—(*a*) Air and sounding pipes are to be fitted in accordance with the requirements of the **Rules for Pumping and Piping**.

(*b*) The height of air pipes, from upper surface of deck to opening, on decks exposed to the weather is to be as follows:—

On the uppermost continuous deck where the draught is the maximum permitted for the dimensions of the ship with the depth D measured to that deck ... ... 36 inches.

On raised quarter decks ... ... 30 inches.

On superstructure decks other than raised quarter decks but including those extending for the full length of the ship ... ... 18 inches.

(*c*) Openings of air and sounding pipes are to be provided with satisfactory arrangements to prevent the free entry of water.

(*d*) Striking plates of sufficient thickness, or their equivalent, are to be fitted under all sounding pipes.

(*e*) In all cargo spaces or coal bunkers, air and sounding pipes are to be well protected and in coal bunkers the protection is to be of steel.

Section 25.

BULWARKS, FREEING PORTS, SCUPPERS, SANITARY DISCHARGES AND SIDE SCUTTLES.

1. **Bulwarks.**—(*a*) Plate bulwarks are to be stiffened by a strong rail section and supported by stays from the deck, spaced not more than six feet apart. Where bulwarks are cut to form a gangway or other opening, stays of increased strength are to be fitted at the ends of the openings. The plating in way of mooring pipes is to be doubled or increased in thickness.

(*b*) The arrangements for continuity of strength at the ends of superstructures are to be as required by **Section 12, clause 3.** Bulwarks should not be cut for gangway or other openings near the breaks of superstructures.

(*c*) In welded ships, the bulwarks should be arranged to ensure their freedom from main structural stresses; welded connections between bulwark plating and the sheerstrake or deck stringer are to be avoided.

(*d*) The bulwarks of ships carrying timber deck cargoes are not to be less than 39 inches in height and are to be additionally stiffened at the upper edge; bulwark stays are to be attached to the deck in way of beams.

2. **Freeing Ports.**—(*a*) Where weather decks are enclosed by bulwarks ample provision is to be made for rapidly freeing the decks from large quantities of water by means of freeing ports.

(*b*) The area of freeing port openings at uppermost continuous decks where the draught is the maximum permitted for the dimensions of the ship with the depth D measured to that deck, and at raised quarter decks is to be as follows :—

Length of Well.	Area on each Side.	Length of Well.	Area on each Side.
Feet.	Square Feet.	Feet.	Square Feet.
15	8	55	12
25	9	65	13
35	10	75	15
45	11	85	17

On superstructures, other than raised quarter decks, but including those extending for the full length of the ship, the area of the openings is to be half the area given above.

In ships having deficient sheer or where there is no free passage for water across the weather deck, the freeing port area is to be suitably increased or open rails are to be fitted.

(*c*) The lower edges of freeing ports are to be as near to the deck as practicable and the openings are to be protected by rails spaced not more than 9 inches apart. If hinged doors are fitted over the openings their hinges are to have brass pins; fittings for keeping the doors closed are not to be provided.

3. **Scuppers.**—(*a*) Scuppers sufficient in number and size to provide effective drainage are to be fitted in all decks.

(*b*) When the weather deck stringer angle is cut in way of scuppers compensation is to be provided.

(*c*) Scupper pipes which drain spaces below the freeboard deck are to be led to the bilges, or may be led overboard provided the spaces drained are above the load waterline and the scuppers are fitted with screw-down non-return valves capable of being operated from a position always accessible and above the freeboard deck. Means are to be provided for showing whether the valves are open or closed.

(*d*) Scuppers draining spaces in intact superstructures or in superstructures having the openings in the end bulkheads closed by strong hinged steel doors may be led to the bilges or may be led overboard and fitted if considered necessary with screw-down non-return valves as required by (*c*) above.

(*e*) Scuppers draining spaces in short superstructures having the openings in the end bulkheads closed by appliances as described in **Section 23, clause 1** (*d*), are to be led overboard, with the exception of the scuppers above the machinery space whic may be led to the bilges where the lower ends of the pipes are to be visible and readily accessible.

(*f*) Scuppers which drain overboard from spaces referred to in (*d*) and (*e*) above and which are not required to have storm valves with positive means of control are to be fitted with non-return valves of automatic type.

(*g*) Scuppers draining spaces in long superstructures having the openings in the end bulkheads closed by appliances as described in **Section 23, clause 1** (*d*) are, within the range of the machinery space, to be led to the bilges where the lower ends of the pipes are to be visible and readily accessible.

Where additional scuppers are required to ensure effective drainage of the spaces clear of the machinery space these scuppers are to be led to the hold bilges and fitted with screw-down valves at the freeboard deck, the valves being controlled from a position which is accessible at all times above the freeboard or superstructure deck. Means are to be provided for showing whether the valves are open or closed.

(*h*) Plans showing the arrangement of scuppers for draining refrigerated cargo compartments are to be submitted for consideration.

4. **Sanitary Discharges.**—(*a*) Sanitary discharges from spaces below the freeboard deck are to be provided with efficient and accessible means of preventing water from passing inboard.

Each discharge is to have a screw-down automatic non-return valve operated from an accessible position above the freeboard deck. Means are to be provided for showing whether the valve is opened or closed.

Alternatively, two automatic non-return valves, without positive means of closing, may be fitted provided the upper valve is in a position which is always accessible for examination.

(*b*) Discharges from spaces within enclosed superstructures are each to be fitted with automatic non-return valves, but arrangements similar to those described in (*a*) above may be required.

5. **Materials for Valves and Pipes.**—Castings enclosing non-return valves are to be of substantial construction. These castings, also the elbow pieces where no valves are required, are to be of approved material other than ordinary cast iron. The length of pipe attached to the valve or elbow piece is to be of galvanised steel of standard steam pipe quality.

6. **Protection of Pipes and Valves.**—In all cargo spaces or coal bunkers, scupper pipes, discharges and screw-down valves and their controls are to be well protected; in coal bunkers the protection is to be of steel.

7. **Side Scuttles.**—Side scuttles and deadlights are to be of approved design and are to be made of approved material other than ordinary cast-iron.

Side scuttles to spaces below the freeboard deck or to spaces within enclosed superstructures are to be fitted with efficient inside deadlights permanently attached and capable of being closed watertight.

In enclosed superstructures permanently allocated to passengers or crew portable deadlights may be provided if stowed adjacent to the scuttles, provided they are accessible at all times in service.

Section 26.

RUDDERS.

1. **Materials.**—(*a*) Steel castings are to comply with the requirements of **Section 9** of the **Rules for Quality and Testing of Materials.**

(*b*) Forgings made of Ingot Steel are to comply with the requirements of **Section 10** of the above Rules.

(*c*) If forgings are made from scrap material, either iron or steel scrap may be used, but a mixture of iron and steel is not permitted.

2. **Diameter of Rudder Head and Mainpiece.**—(*a*) The diameter of the rudder head is to be determined from **Table 44** and associated Notes.

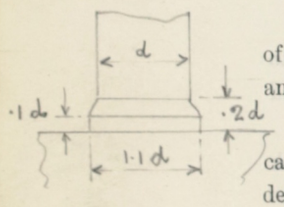
(*b*) The mainpiece of rudders with cast or forged frames is to be of the same diameter at the top pintle as the rudder head and is to taper evenly to the heel, where the diameter is not to be less than 75 per cent of that of the head.

(*c*) If the supports of the rudder are so arranged that considerable bending stresses may occur in the mainpiece and head these are to be suitably strengthened.

3. **Single Plate Rudders.**—(*a*) The thickness of plates and scantlings of arms of single plate rudders are to be determined from **Table 45** and associated Notes.

(*b*) Arms are to be arranged on alternate sides of the plate and are to be shrunk on to the mainpiece and keyed. In way of each arm the mainpiece is to be increased in diameter by 10 per cent; this increased diameter is to extend above and below the arm for a distance equal to the increase in diameter and beyond these points is to be gradually reduced to the normal diameter of the mainpiece over a distance of one-fifth of the normal diameter.

i.e INCREASED DIAM. TO EXTEND FOR DISTANCE EQUAL TO 10% OF NORMAL DIAM. & TO TAPER OVER 20% OF NORMAL DIAM.



(*c*) The thickness of the key is to be 10 per cent of the normal diameter of the mainpiece at each arm, and the width is to be twice the thickness.

4. **Double Plate Rudders.**—(*a*) The scantlings of cast or forged frames of double plate rudders will be determined in relation to their design. The thickness of the plates is to be derived from **Table 46** and associated Notes.

(*b*) The scantlings of rudders with plate frames will depend upon the arrangements adopted. The thicknesses of the outside plates and of the horizontal and vertical web plates are to be determined from **Table 46** and associated Notes. Special attention is to be given to the attachment of the pintles and rudder coupling to the body of the rudder.

(*c*) The internal surfaces of double plate rudders are to be efficiently coated and means for draining the rudder are to be provided.

5. **Pintles.**—(*a*) The scantlings of the pintles are to be determined from **Table 47** and associated Notes.

(*b*) The distance between the top pintle and the bearing of the rudder stock should be as short as possible; where the ratio of the unsupported length to the diameter of stock is excessive the diameter of the stock may require to be increased or the length reduced by fitting an additional and accessible bearing.

(*c*) Where liners to pintles are fitted they are to be shrunk on to the pintles or otherwise efficiently secured.

6. **Couplings.**—(*a*) The scantlings of couplings are to be determined from **Table 48** and associated Notes.

(*b*) The bolts are to be "fitted" and suitable arrangements are to be made to lock the nuts.

7. **Riveting.**—The diameters of rivets in rudder arms are given in **Tables 45** and **46.**

The rivets are to be spaced $4\frac{1}{2}$ diameters apart and the holes are to be countersunk. Where the breadth of the arm exceeds $4\frac{1}{2}$ inches the riveting is to be reeled and if the breadth exceeds 7 inches two complete rows of rivets are to be fitted, but, except at the outer ends of the arms, the rivets are not to be directly opposite to each other.

8. **General.**—(*a*) Suitable arrangements are to be provided to prevent the rudder from lifting.

(*b*) When the weight of the rudder is supported by a carrier bearing attached to the rudder head the structure in way is to be adequately strengthened for that purpose. The plating under all rudder head bearings or rudder carriers is to be increased in thickness or doubled.

(*c*) In ships with a high astern speed the scantlings of rudder are to be specially considered.

For Strengthening for Navigation in Ice *see* **Section 10, clause 7.**

Section 27.

STEERING GEAR.

1. **Steering Gear.**—(*a*) All ships are to be provided with two independent means of steering. In ships exceeding 200 feet in length one of the gears is to be operated by power sufficient to put the rudder from hardover to hardover in 30 seconds while the ship is going ahead at full sea speed. All gears are to be fitted and tested under working conditions to the satisfaction of the Surveyors.

(*b*) Particulars of the proposed alternative means of steering are to be submitted for approval. Hand gear of the right and left handed screw and nut type is not to be fitted in ships exceeding 300 feet in length.

(*c*) No additional means of steering will be required where electric or electric-hydraulic steering gears are fitted having two independent motors or sets of pumps and motors with separate leads from the source of power. With steam hydraulic steering gears similar arrangements will be accepted.

(*d*) After hand steering wheel and gear in ocean going ships are to be adequately protected.

(*e*) The steering gear is to be secured to the seating by "fitted" bolts and suitable buttressing arrangements are to be provided.

2. **Tillers and Quadrants.**—The scantlings of tillers and quadrants are to be as given in **Tables 49** and **50**. Tillers and quadrants are to be shrunk on or bolted to the rudder head, in addition to being secured by a key of suitable dimensions. The keyways are to have rounded ends. The thickness of quadrant plates is to be 1 per cent of the radius given in the table. The area of the arms at ends may be one-third of the area given in **Table 49**. Arms of loose quadrants not keyed to the rudder head may be of these reduced dimensions throughout their length, and the depth of the boss may be reduced by 10 per cent.

3. **Rod and Chain Gears.**—(*a*) Steering rods and chains are to have the diameters required by **Table 49** for the radius of quadrant given therein. Shackles, shackle pins, links and other connections are to be suitable for the size of chain.

(*b*) All steering chains are to be subjected to the breaking and proof tests for short link chains given in **Section 14** of the **Rules for Quality and Testing of Materials.** These tests are to be carried out at a proving establishment recognised by the Committee and the certificates are to be produced.

(*c*) The leads of the steering chains are to be as direct as possible and sharp bends are to be avoided. The diameters of leading block sheaves, measured at the centre of the chain, are to be not less than sixteen times the diameter of the steering chains; the pins of the sheaves are to have not less than twice the diameter of the chains.

(*d*) A set of spares is to be provided consisting of one complete spring buffer and one extra spring, two tested chains each equal to the longest length in the gear, two Warwick screws, four shackles, four connecting links and four rod pins.

In ocean going ships, the speed of which is 12 knots and above, one buffer spring, one Warwick screw and one length of chain may be dispensed with.

In ships engaged on short sea routes which have either a main gear which is hand operated at sea or an auxiliary gear, independent of the rods and chains, which can be effectively operated at sea, the spare gear may be confined to sufficient shackles or split links to enable repair of the gear to be readily effected in the event of its breakdown at sea. In all other ships engaged on short sea routes, the spare gear is to be as required for ships the speed of which is 12 knots and above.

4. **Springs.**—Springs, buffers or equivalent arrangements are to be fitted to all main steering gears.

5. **Locking or Brake Gear.**—An efficient locking or brake arrangement is to be fitted to keep the rudder steady when a change of gear is required.

6. **Rudder Stops.**—Stops for the rudder are to be provided and strongly secured to the deck in way of the tiller or quadrant tiller. Stops on the steering engine are to be arranged at a smaller angle of helm than those for the rudder.

Section 28.

MASTS AND RIGGING.

1. **Masts and Derrick Posts.**—(*a*) The scantlings of stayed and unstayed masts and derrick posts equipped with derricks of normal outreach intended for a working load not exceeding 8 tons each are to be determined from **Table 51** and associated Notes. For stayed masts the Table does not provide for more than one derrick plumbing any one hatch or for two derricks working outboard; the load for use in the Table is the working load of

the heaviest derrick on the mast. For unstayed masts, or derrick posts, the Table provides for two derricks working simultaneously in one direction and the load to be used in the Table is the sum of the working loads of the two derricks.

(*b*) When the working load of any derrick exceeds 8 tons, or when the length of a derrick exceeds the length of the mast or derrick post by more than 20 per cent or where in stayed masts the arrangement of standing rigging differs from that given in **clause 2**, the scantlings and arrangements will be specially considered, if desired.

(*c*) Masts and derrick posts are to be increased in thickness, or doubled, at the heel, deck and hounds and in way of the derrick fittings; they are to be efficiently supported below the heel.

2. **Standing Rigging.**—(*a*) Two shrouds, of standing rigging quality as defined in **Section 15, clause 3** of **Rules for Quality and Testing of Materials**, are to be fitted on each side of stayed masts. The shrouds are to be attached at a distance forward and aft of the mast equal to one quarter of the beam of the ship or one quarter of the length of the mast, whichever is the greater. The circumference of each shroud is to be $2\frac{1}{2}$ inches where there are no derricks, 4 inches where four-ton derricks are fitted, and 5 inches where eight-ton derricks are fitted. Alternative arrangements of standing rigging will be considered in conjunction with the scantlings of the masts. Top masts are to be efficiently stayed.

(*b*) Particular attention is to be paid to the strength and workmanship of all parts of the rigging and its connections. Smithwork is to be of best quality wrought iron or mild steel. The hull structure is to be effectively strengthened in way of chain plates or similar fittings. Standing rigging is to be properly set up.

3. **Masts with Outriggers.**—Where outriggers at mast heads are of unusual spread the scantlings of masts and rigging will be specially considered.

For Riveting *see* **Table 52 (G.)**.

For Lightning Conductors *see* **Rules for Electrical Equipment, Section 19.**

Section 29.

CEILING AND CARGO BATTENS.

1. **Ceiling.**—(*a*) In single bottom ships close ceiling is to be laid on the floors to the upper part of the bilges. Limber boards are to be arranged to provide easy access to the bilges.

(*b*) In ships having double bottoms ceiling is to be laid over the bilges and under hatchways; the ceiling over the bilges is to be arranged with hatches which are readily removable. Ceiling under hatchways may be omitted provided the thickness of the inner bottom plating in way is increased by ·08 inch.

(*c*) The spaces between the frames at the top of the bilge ceiling are to be closed by wood chocks and cement or other suitable means.

(*d*) Ceiling is to be laid either directly on the inner bottom plating embedded in a substantial composition such as Stockholm tar and cement, or on battens providing a clear space of at least half an inch for drainage. (*See also* (*g*) *below*.)

(*e*) The thickness of wood ceiling is not to be less than $2\frac{1}{2}$ inches in ships exceeding 200 feet in length and 2 inches in smaller ships.

(*f*) Where the covers or fittings of the manholes of the inner bottom in cargo holds project above the plating they are to be protected by a steel coaming around each manhole, fitted with a hatch of wood or steel.

(*g*) The requirements for ceiling over double bottom tanks where oil fuel is carried are given in **Section 20, clause 12** (*d*), and for refrigerated holds in **Section 3, clause 5, of Rules for Refrigerating Machinery and Appliances of Ships.**

(*h*) For ceiling in ships which are to be regularly discharged by grabs, *see* **Section 5, clause 7** (*b*).

2. **Cargo Battens.**—(*a*) Cargo battens are to be fitted in the holds from above the upper part of the bilge to the under side of beam knees, and in all cargo spaces in 'tween decks and superstructures up to the under side of beam knees.

(*b*) Wood cargo battens are to be 2 inches in thickness in ships exceeding 200 feet in length and $1\frac{1}{2}$ inches in smaller ships; the clear space between the adjacent rows is not to exceed 9 inches.

(*c*) Battens may be dispensed with at the request of the Owners, when the Certificate of Classification will be endorsed "Cargo battens not fitted"; this notation will also appear in the Register Book.

Section 30.

PROTECTION OF STEELWORK.

1. **Cementing.**—(*a*) In single bottom ships the shell plating and framing to the upper part of the bilges are to be effectively covered with Portland or other approved cement, mixed with sand to form a suitable composition. Free edges of cement are to be of proper thickness. Clear watercourses are to be maintained throughout.

(*b*) In double bottoms under the boiler room the frames and shell plating are to be efficiently cemented unless the tanks are used solely for oil fuel; elsewhere inside the double bottom the cement may be dispensed with. The bilges are to be cemented or coated with a suitable composition; if cement is used it should not extend above the upper edge of the inboard flange of the margin angle.

(*c*) When it is desired to apply asphalt or a similar composition its use is to be sanctioned by the Owners and approved by the Committee.

2. **Painting.**—All steelwork not protected as required by **clause 1** is to receive at least two coats of paint of suitable composition except inside tanks intended for oil; tanks not intended for oil may be coated with cement wash.

3. **General.**—(*a*) Care is to be taken that all surfaces are thoroughly cleaned and in a suitable condition to receive the coating to be applied.

All practicable steps should be taken to ensure that the mill scale has been removed or weathered off before painting and with this in view the coating of external steelwork should be delayed as long as possible.

(*b*) Experience has shown that it is highly desirable to dry-dock ships reasonably soon after launching in order to clean and recoat the bottom.

Section 31.

RIVETING.

1. **Connections.**—(*a*) The requirements for riveted connections and the diameter and spacing of rivets in the various parts of the structure are given in **Table 52.** The diameter of the rivets is to be regulated, in general, by the greater thickness of the parts to be connected, but where the difference is considerable special consideration will be given. (*See also* Notes to **Table 52.**) Where frame spacing wider than that given in the Tables is adopted the diameter and the number of rows of rivets are to be regulated by the thickness of the plating required at the Table frame spacing.

(*b*) The breadths of the flanges of connecting angles or other sections are to be generally not less than four times the diameter of the rivet for rivets up to $\frac{7}{8}$ inch in diameter and three and one-half times for rivets of 1 inch diameter or over.

(*c*) Chain riveting is to be adopted for the butts and seams of plating. In the connections to bar keels, stems and sternframes and in double riveted stringer angles, boundary angles and frame connections the rivets are to be reeled.

2. **Form of Rivets.**—Rivets are to be suitably formed to fill the rivet holes completely. Where the holes have been punched the rivets are to be increased under their heads. The heads of pan headed rivets are to have a depth of ·7 and a diameter at the bottom of the head of 1·6 times the diameter of the rivet. Where countersunk headed rivets are used the heads are to be suitable for the countersinking of the material.

3. **Countersinking.**—(*a*) Rivet holes are to be countersunk on the caulking side of plating, and in boundary connections, of shell, weather decks, inner bottom, double bottom tank ends, crowns and bulkheads of peak tanks, deep tanks and oil fuel bunkers. The holes in the margin plate to take gusset plate rivets are also to be countersunk.

(*b*) The countersinking of the holes is to extend through at least nine-tenths of the thickness of the plates or angles where the thickness does not exceed ·50 inch and through at least eight-tenths where the thickness is above ·50 inch.

(*c*) The angle of countersink for material not exceeding ·50 inch in thickness is to be about 60 degrees; for plating exceeding this thickness the angle is to be about 45 degrees.

4. **Workmanship.**—*See* **Section 32.**

5. **Welded Connections.**—The requirements for welded connections are contained in the **Rules for Electric Arc Welding in Ship Construction, Section 3.**

Section 32.

WORKMANSHIP.

1. **General.**—(*a*) Workmanship is to be well executed and submitted to close inspection throughout the preparation and building of the ship. The various parts of the structure are to be faired and properly closed.

(*b*) Punches, dies and shears are to be maintained in good condition and the clearance between the punch and the die is to be kept as small as possible.

2. **Plating.**—(*a*) The preparation of plate edges is to be accurate and uniform. Shearing is to be carried out from the faying surface wherever practicable. Any burr on plates or sections preventing the closing of work is to be removed.

(*b*) All caulking edges are to be planed, flame cut, chipped fair, or otherwise suitably prepared.

3. **Liners and Joggling.**—(*a*) Where plates or sections are joggled care is to be taken that the joggle is of the correct depth and rivet holes are to be clear of the joggle.

(*b*) Liners, if fitted, are to be in one piece of the proper thickness and of breadth not less than the flange of the faying section. Holes in liners are to be of the same diameter as those in the plate and section.

4. **Riveting.**—(*a*) Rivet holes may be drilled or punched and are to be countersunk where required by **Section 31, clause 3.** Punching is to be carried out from the faying surface wherever practicable.

(*b*) Any burr caused by drilling or punching is to be removed before the work is closed for riveting.

(*c*) Unfair rivet holes are to be remedied by reamering and rivets of an appropriate diameter are to be used. Where necessary the holes are to be recountersunk and the faying surfaces cleaned.

(*d*) Rivet holes in the frames at the turn of the bilges and at bossing are not to be drilled or punched to their full diameter before the frames have been shaped.

(*e*) Service bolts of requisite size and number are to be used to hold the parts in position and in close contact.

(*f*) The heads of the rivets are to be properly laid up and the work performed so that the holes are completely filled. Points of rivets are to be kept full but are not to be spread over the plating. In holes which are not countersunk the rivets are to be finished with specially full or snappoints.

(*g*) Rivets in all parts are to be spaced to ensure the efficient closing of work. Particular care is to be taken with three-ply riveting.

5. **Caulking.**—Caulking is to be thoroughly executed. Stopwaters of suitable material may be fitted where necessary; otherwise the use of soft packing is to be kept to a minimum. Thick packing is not to be used.

6. **Oil-tight Work.**—(*a*) The requirements of **clauses 1 to 5** are to be complied with.

(*b*) Faying surfaces are, in general, to be fitted steel to steel; but where packing is necessary the material used is to be as thin as possible and not soluble in oil.

(*c*) Where there may be difficulty in securing fairness rivet holes are to be drilled in position or punched small and reamered.

(*d*) Where boundary angles are double both flanges of each bar are to be caulked and countersunk headed rivets are to be used.

(*e*) Where fitted on caulking surfaces angle or T bar connections are to be caulked.

(*f*) Attachments of fittings are to be made as far as possible without piercing the plating; where through fastenings are necessary they are to be tapped and efficiently secured to the plating.

7. **Welded Construction.** — For workmanship in welded construction *see* **Section 2** of **Rules for Electric Arc Welding in Ship Construction.**

Section 33.

EQUIPMENT.

1. **General.**—(*a*) The regulations governing the assignment of the Figure ✝ for equipment are contained in **clause 2** of the **General Regulations for the Classification of Steel Ships and their Machinery.**

(*b*) To entitle a ship to the Figure ✝ the equipment is to be in accordance with the following requirements and **Table 53.** For ships engaged on a special or restricted service an equipment less than the Table requirements may be approved by the Committee if considered suitable for the particular service on which the ship is to be engaged.

2. **Equipment Numeral.** — (*a*) The equipment of anchors, chain cables, wires and ropes given in **Table 53** is based on a Numeral L (B + D), where L, B and D are as defined in **Section 2**; D is to be measured to the uppermost continuous deck.

An addition to this Numeral for superstructures and erections above the uppermost continuous deck is to be made as follows:—

For a raised quarter deck the product of the length and height in feet.

For a poop, bridge, forecastle, or other similar superstructure, 75 per cent of the product of the length and height in feet.

For deckhouses and other erections which exceed either in length or breadth one half the breadth of the ship, 50 per cent of the product of the length and height.

(35) TAKE D AS 1·5 d (EVEN IF THIS DOES NOT COINCIDE WITH A DECK)
AND ALL ABOVE AS AN ERECTION.

(*b*) The Equipment Numeral for large passenger ships having several tiers of erections will be specially considered.

3. **Anchors.**—(*a*) The weight of bower anchor given in **Table 53** is that of the first bower. Provided the collective weight of the bower anchors is not less than that given in the Table the anchors may be of equal weight, or alternatively, the second bower may be 7½ per cent. and the third 15 per cent. lighter than the Table weight of the first bower.

(*b*) Anchors are to be of approved design. The heads of stockless anchors are not to be less than 60 per cent of the total weight of the anchor. Where anchors with stocks are provided the weight of the stock is to be 25 per cent of the weight "ex stock" given in the Table.

4. **Chain Cables.**—(*a*) The form and proportions of the links and shackles are to be in accordance with recognised practice.

(*b*) The minimum weights of chain cable given in **Table 53** include two end shackles for each cable (i.e., four end shackles for each outfit of two cables) and two end shackles to each stream chain.

(*c*) The diameters given in the Table apply to chain cables of wrought iron. Steel cables of a higher tensile strength made by an approved process, and which comply with the proof and breaking tests required for Cables of Special Steel by the Table in **Section 14** of the **Rules for Quality and Testing of Materials**, may be of a diameter reduced below the requirements of **Table 53** as follows :—

P. 476.

Table Size.	Reduction.
Inches.	Inches.
$\frac{14}{16}$ — $\frac{15}{16}$	$\frac{1}{16}$
1 — $1\frac{3}{16}$	$\frac{2}{16}$
$1\frac{4}{16}$ — $1\frac{10}{16}$	$\frac{3}{16}$
$1\frac{11}{16}$ — $2\frac{1}{16}$	$\frac{4}{16}$
$2\frac{2}{16}$ — $2\frac{9}{16}$	$\frac{5}{16}$
$2\frac{10}{16}$ — $3\frac{2}{16}$	$\frac{6}{16}$
$3\frac{3}{16}$ — $3\frac{8}{16}$	$\frac{7}{16}$

5. **Testing of Equipment.**—(*a*) All anchors and chain cables are to be tested at establishments and on machines recognised by the Committee or controlled by a Government, Municipal or similar responsible body, and in accordance with **Sections 12, 13,** and **14,** of the **Rules for Quality and Testing of Materials.**

Test Certificates showing particulars of weights of anchors, or size and weight of cable and of the test loads applied are to be furnished. These certificates are to be examined by the Surveyors when the anchors and cables are placed on board the ship.

(*b*) The notation " Lloyd'sA&CP " will be entered in the Register Book when the anchors and chain cables have been tested at licensed Proving Establishments in Great Britain or have been tested under the supervision of the Society's Surveyors at other Proving Establishments on machines recognised by the Committee.

(*c*) When the anchors and chain cables have been tested on a machine controlled by a Government, Municipal, or similar responsible body in accordance with the Rule requirements, although not under the supervision of the Society's Surveyor's, and test certificates signed by a competent Authority are produced for the Surveyor's examination and verified, the equipment will be accepted, but the notation "Lloyd's A&CP " will not be made in the Register Book.

(*d*) Anchors and chain cables supplied to ships registered in the United Kingdom are required by Statute to be tested at a licensed Proving Establishment in Great Britain.

(*e*) Steel wire ropes are to be tested as required by **Section 15** of the **Rules for Quality and Testing of Materials.**

6. **Arrangements for Working and Stowing Anchors and Cables.**—(*a*) A windlass of sufficient power and suitable for the size of chain cable is to be fitted and efficiently bedded and secured to the deck. The thickness of the deck in way of the windlass is to be increased and adequate stiffening is to be provided, to the Surveyor's satisfaction.

(*b*) An easy lead of the cables from the windlass to the anchors and chain locker is to be arranged.

(*c*) Hawse pipes are to be of ample thickness and of a suitable size and form to house the anchors efficiently. Substantial chafing lips are to be provided at the shell and deck. The shell plating and framing in way of the hawse pipes are to be reinforced as necessary.

(*d*) The chain locker is to be of a capacity and depth adequate to provide an easy direct lead for the cable into the chain pipes, when the cable is fully stowed. Chain

or spurling pipes are to be of suitable size and provided with chafing lips. The locker is to be centrally divided between the port and starboard cables and provision is to be made for securing the inboard ends of the cables to the structure.

(*e*) Satisfactory arrangements are to be made for the stowage and working of the stream anchor.

7. **Boats and Davits.**—(*a*) All ships are to be provided with boats sufficient in number and size for the intended service. The boats are to be maintained in good condition.

(*b*) Davits are to be of adequate strength and stiffness and designed for controlled and rapid lowering of the boats.

The structure in way of the davits is to be strengthened to support the additional loads.

For the equipment of Tugs *see* **Section 34, clause 9.**

Section 34.

TUGS.

1. **General.**—The scantlings and arrangements of Tugs are to be as required by the Rules and Tables for Steel Ships except where otherwise specified in this Section.

2. **Class.**—(*a*) Tugs built in accordance with the requirements of this Section will be classed 100A with the notation "For Towing Services."

(*b*) Where tugs are intended for service in sheltered waters only, the class will be A "For Towing Services" with a notation indicating the limits of the service. Suitable modifications in the scantlings and equipment may be approved by the Committee.

(64) No increase to side frames in tugs & trawlers if floor bkts omitted, & depth of floors increased 15%. In these ships frame need not be reinforced at junction with floor frame.

3. **Floors.**—Floors in tugs having single bottoms may be flanged 3½ inches on the upper edge instead of having reversed frames, except in the engine room and under the boiler bearers where double reversed frames are to be fitted as required by **Section 4, clause 2** (*b*).

(103) Where reverse bars are fitted they need not be more than equivalent to 3½" flange.

4. **Keelsons.**—The scantlings of keelsons are to be in accordance with the requirements for Tugs given in **Table 5.**

5. **Bulkheads.**—Watertight bulkheads are to be constructed generally as required by **Section 16,** but the stiffeners may be determined from **Table 35.**

6. **Machinery Casings.**—(*a*) Machinery casings are not to be less in height than three feet above the upper surface of the deck.

Casings extending to the bottom of the beams are to be connected to the beams; the deck connection may be made by a single riveted angle or equivalent. If the casings do not extend to the bottom of the beams the casing connection to the deck is to be double riveted or equivalent.

(*b*) Machinery casings are to be made watertight and hose tested.

(*c*) A strong through beam is to be fitted at the deck level between the engine room and boiler room openings. A through beam should also be fitted in motor tugs when the machinery opening is of considerable length, and the casing stiffened by webs.

7. **Panting and Strengthening of Bottom Forward.**—The arrangements to resist panting, required by **Section 9** do not apply to tugs below 150 feet in length. In tugs 150 feet or more in length additional stiffening is also to be fitted in the 'tween decks throughout the panting region. The requirements of **Section 8** for strengthening of bottom forward do not apply to tugs.

8. **Hatchways.**—Hatch coamings are not to be less in height than 12 inches above the upper surface of the deck The closing arrangements are to be equivalent in strength and efficiency to the requirements of **Section 23** for hatchways having 24 inch coamings.

9. **Equipment.**—*See* **Section 33, clause 1** (*a*). To entitle tugs having the class 100A to the Figure 1, the equipment is to be determined from **Table 54** and associated Notes. The equipment numeral is to be L (B + D) without addition for casings or other erections.

71, Fenchurch Street, London, E.C.3.
4th November, 1948.

ELECTRIC ARC WELDING

IN

SHIP CONSTRUCTION.

INDEX

ELECTRIC ARC WELDING IN SHIP CONSTRUCTION.

	Section.	Clause.	Page.
G			
General	1	—	67
P			
Periodical Inspection at Makers' Works	5	—	70
T			
Tables	—	—	71
Tests for Electrodes	4	—	69
„ „ bend tests ...	4	4(*b*)	69
„ „ butt welds ...	4	4(*a*)	69
„ „ chemical analysis ...	4	9	70
„ „ deposited material tests	4	8	70
Tests for Electrodes—(*continued*)			
„ „ fillet weld tests ...	4	6	69
„ „ shear tests	4	5	69
„ „ vertical and overhead tests	4	7	69
W			
Welded Connections	3	—	68
„ „ additional attachment	3	6	68
„ „ butt welds	3	1	68
„ „ fillet welds	3	2	68
„ „ intermittent fillets ...	3	4	68
„ „ overlaps	3	5	68
„ „ tee connections ...	3	3	68
Workmanship	2	—	67

RULES FOR ELECTRIC ARC WELDING IN SHIP CONSTRUCTION.

Section 1.

GENERAL.

1. The use of Electric Arc Welding in the structure of ships intended to be classed with the Society is subject to compliance with the following requirements, and to:—

(*a*) Plans being submitted showing particulars and scantlings of the welding arrangements proposed; where welding is to be extensively adopted for the main structure, the assembly and welding sequences are also to be submitted.

(*b*) The electrodes used complying with the tests and requirements set forth in Sections 4 and 5.

(*c*) The workmanship being to the satisfaction of the Society's Surveyors.

2. Particulars indicating the principal parts which are welded will be given in the Register Book as deemed desirable by the Committee.

3. Special attention is to be paid to structural continuity. Abrupt changes of shape or section are to be avoided; corners of all openings should be well rounded.

4. The thickness of plating may in certain cases require to be increased to take account of the greater area of panels resulting from the omission of faying flanges in the supporting structure.

5. The structural arrangements are to be such as will ensure easy access for welding operations, and that downhand welding can be employed where practicable.

6. The intersection of welded connections should be avoided where possible. Where stiffening members cross butts or seams of plating the webs of the stiffening members should be scalloped. The webs of stiffening members and bilge keels should also be scalloped at their butts.

7. The type and disposition of connections and their sequences of welding are to be so arranged that stresses resulting from welding operations are reduced to the minimum.

8. Where the structure embodies both welding and riveting, welded joints are in general to be completed before riveting in their vicinity. Individual connections which are proposed to be part welded and part riveted shall not be adopted unless specifically approved.

9. Alternative proposals or methods of welding considered by the Committee to be equivalent to those set forth in the Rules will be accepted.

Section 2.

WORKMANSHIP.

1. Welding operators are to be proficient in the type of work on which they are engaged. Trained supervisors are to be provided to ensure effective control at all stages during assembly and welding. The welding plant and appliances are to be suitable for the purpose intended and are to be maintained in an efficient condition.

2. Procedures for the welding of all joints are to be established for the types of electrode, edge preparation and welding position proposed to be adopted. For this purpose, the Surveyors may require sample tests to be prepared under similar conditions to those which will obtain during construction.

The diameter of electrode, current, voltage, rate of deposit and number of runs are to conform, as far as practicable, to those established in accordance with the preceding paragraph. Provision is to be made for checking the current in the vicinity of the arc.

3. The preparation of plate edges is to be accurate and uniform.

All joints are to be properly aligned and closed or adjusted before welding.

Where excessive gaps exist between surfaces or edges to be joined, the corrective measures adopted are to be to the satisfaction of the Surveyors.

Excessive force is not to be used in fairing and closing the work, and rigid restraint during welding operations is to be avoided.

4. The surfaces of all parts to be welded are to be clean, dry, and free from rust, scale and grease.

5. All welds are to be sound, uniform and substantially free from slag inclusions and porosity. Care is to be taken to ensure thorough penetration and fusion, and the avoidance of undercut.

The surfaces and boundaries of each run of deposit are to be thoroughly cleaned and freed from slag. Defective sections of welds are to be cut out and rewelded.

6. Before a sealing run is applied to a butt weld, the clean metal of the original root run is to be exposed.

7. Adequate protection is to be provided where work is required to be carried out in exposed positions during wet, windy or severely cold weather.

Section 3.

WELDED CONNECTIONS.

1. **Butt Welds.**—Butt welds should be adopted in preference to overlaps in shell and strength deck plating and other important structural connections. In general the edges to be joined by manual welding are to be bevelled on one side of the plating or on both sides to provide an included angle of about 60 degrees. Where the plates are bevelled on one side only a sealing weld is to be applied to the reverse side of the butt.

Where it is desired to adopt other forms of edge preparation full details are to be submitted.

2. **Fillet Welds.**—(*a*) The dimensions of fillet welds for various structural connections are to be as required by **Tables 1**, 2 and 3.

(*b*) The size of fillet weld given in **Table 1** is the minimum length of leg of the fillet. The throat thickness of the weld is to be 70 per cent. of the leg length.

3. **Tee Connections.**—(*a*) The leg length of the fillets is to be governed by the thickness of the abutting plate or web. Where the difference between the thicknesses of the parts to be joined is considerable, the size of the fillet will be specially considered.

(*b*) All connections in **Table 2** are to have double continuous fillet welds. Intermittent welding may be adopted for the connections in **Table 3**.

4. **Intermittent Fillets.**—(*a*) The length of intermittent welds is to be measured over the correctly proportioned fillet, clear of end craters.

(*b*) Where short intermittent fillets are adopted, they are to have a minimum length of 3 inches. Their size is to be as required for **Type 1, Table 1**, with a distance centre to centre not exceeding that indicated in **Table 3**.

(*c*) Where long intermittent fillets are adopted, they are to have a maximum length of about 12 inches, and are to be disposed on alternate sides of the web. They are to be of the size required by **Type 2, Table 1**. Where staggered intermittent fillets are required by **Table 3**, the long intermittent fillets are to have a distance centre to centre equal to their length. Where chain intermittent fillets are required by **Table 3**, the long intermittent fillets are to overlap so that the distance centre to centre is equal to two-thirds of their length.

(*d*) **As an alternative to staggered intermittent welding, double continuous fillets of the size** required for **Type 3, Table 1**, may be adopted. Where chain welding is required, the size of the continuous fillets **is to be as required for Type 2, Table 1.**

(*e*) Intermittent fillets are to be doubled at, and carried round the ends of brackets, of hold frames, longitudinals, beams, bulkhead and floor stiffeners, and of floors to shell, inner bottom and centre girder.

5. **Overlaps.**—Where overlapped joints of plating are adopted, the breadth of the overlap is to be four times the thickness of the thinner of the plates so joined, but need not exceed 2 inches. Particulars of the welding are to be submitted.

6. **Additional Attachment.**—Welded connections may be required to be increased to meet particular local stresses, and also where the spacing or span of stiffening members is increased above Rule.

Section 4.

REGULATIONS AND TESTS FOR THE APPROVAL OF ELECTRODES.

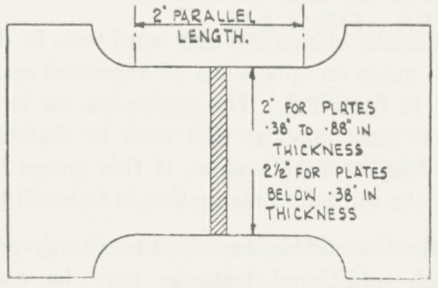
1. The manufacturers' plant and method of production of the electrodes are to be such as to ensure reasonable uniformity in manufacture.

2. Electrodes will be approved by the Committee subject to compliance with the following tests.

The test pieces are to be prepared in the presence of the Society's Surveyor and all tests carried out under his supervision. The steel used in the preparation of the test pieces is to comply with the requirements of **Section 4** of the **Rules for Quality and Testing of Materials.**

3. All test specimens are to be prepared and tested in duplicate. If one specimen fails to satisfy the test, two further specimens may be prepared, both of which must prove satisfactory.

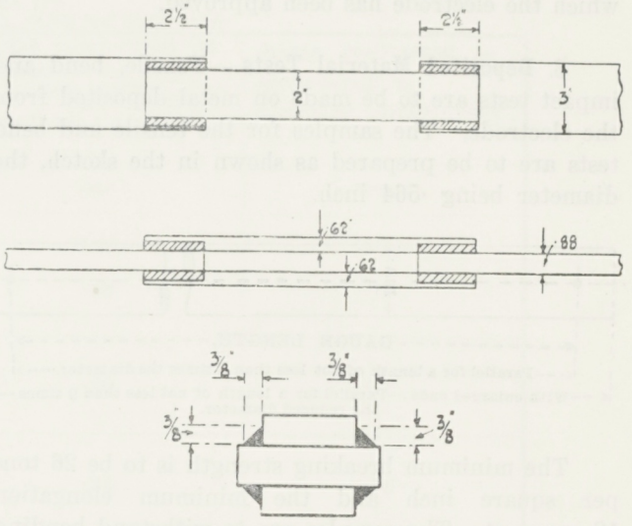
4. **Butt Welds.** (*a*) **Tensile Tests.**—Tensile test specimens of the form shown in the sketch are to be prepared. One of the specimens is to be of the maximum thickness which would normally be welded with square edges, and others, which are to be welded with V butts, are to be ·38, ·62 and ·88 inch in thickness. The surfaces of the welded joints are to be rendered flush on both sides.



The mean tensile strength of the test specimens for each thickness is to be not less than 26 tons per square inch.

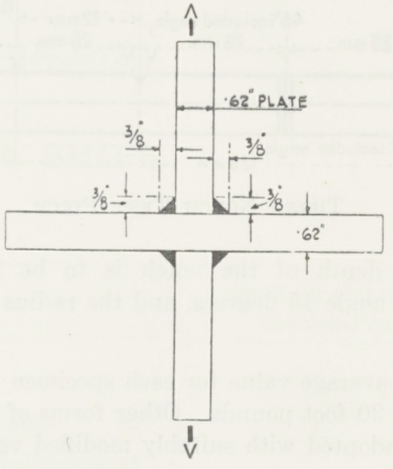
(*b*) **Bend Tests.**—Bend tests are to be made on specimens similar to those shown above from material ·38 and ·88 inch in thickness. These are to withstand bending without fracture through an angle of 90 degrees over a bar of diameter equal to four times the thickness of the test piece. The rough edges of the samples may be removed by filing or grinding, and the test is to be made so that the wide part of the vee is in tension.

5. **Shear Tests.**—Shear tests are to be carried out on specimens prepared as shown on the sketch.



The shear strength of the welds is to be not less than 17 tons per square inch, calculated on the throat thickness.

6. **Fillet Weld Tests.**—Fillet weld tests are to be made on samples 2 inches in width as shown in the sketch.

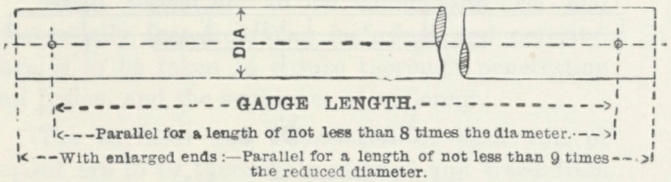


They are to withstand a tensile load, applied in the direction shown, of 73 × t tons, t being the throat thickness of the welds.

7. **Vertical and Overhead Tests.**—Where it is desired by the Manufacturers to demonstrate that an electrode is suitable for vertical or overhead welding, tensile and bend tests are to be made from plates ·38 inch in thickness, together with fillet weld tests, all as set forth above, for each position for which approval is sought.

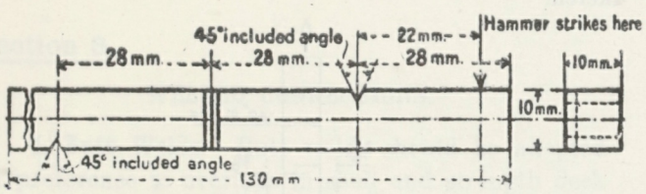
An indication will be given in the List of Approved Electrodes of the positions of welding for which the electrode has been approved.

8. **Deposited Material Tests.**—Tensile, bend and impact tests are to be made on metal deposited from the electrode. The samples for the tensile and bend tests are to be prepared as shown in the sketch, the diameter being ·564 inch.



The minimum breaking strength is to be 26 tons per square inch and the minimum elongation 18 per cent. The samples are to withstand bending to 120 degrees without fracture over a bar having a diameter twice the diameter of the test piece.

The impact tests are to be made on a standard form of Izod test piece as shown in the sketch.



THREE NOTCH TEST PIECE.

The depth of the notch is to be 2 mm. the included angle 45 degrees, and the radius at the root ·25 mm.

The average value for each specimen is to be not less than 30 foot pounds. Other forms of impact test may be adopted with suitably modified values.

9. **Chemical Analysis.**—Chemical analyses of the metal of each type of electrode and of the deposited material of a weld made by the same electrode are to be supplied.

10. The Committee is to be notified of any alteration proposed to be made in the process of manufacture subsequent to approval.

11. Each carton or package of approved electrodes is to contain a certificate from the manufacturer on the following lines :—

"The ——— Company certifies that the composition and quality of these electrodes conform with those of the electrodes used in making the test pieces submitted to and approved by the Committee of Lloyd's Register of Shipping."

Section 5.

PERIODICAL INSPECTION OF MAKERS' WORKS.

1. All establishments where approved electrodes are manufactured shall be subject to periodical inspection by the Society's Surveyors. These visits will take place as may be considered necessary by the Committee but at least once a year. On these occasions samples, selected by the Surveyors, of each of the electrodes manufactured by the Makers and appearing in the Society's Approved List, will be subjected to the tests given below.

2. Tensile, elongation and bend tests in duplicate are to be made on specimens of deposited material as set forth in Section 4. The specimens for tensile and elongation tests may be ·424 inch in diameter with a gauge length of 1½ inches; if this gauge length is adopted, the minimum elongation is to be 23 per cent.

3. The Committee may require, in any particular case, such additional tests as may be considered necessary.

By order of the Committee,

P. E. CLEMENT,
Secretary.

71, FENCHURCH STREET, LONDON, E.C.3.
15th December, 1949.

TABLE 1.

FILLET WELDS.

PLATING THICKNESS. (*See* Section 3, clause 3 (*a*).)	SHORT INTERMITTENT	LONG INTERMITTENT AND DOUBLE CONTINUOUS AS ALTERNATIVE TO CHAIN INTERMITTENT. LEG LENGTH. (*See* Section 3, clause 2 (*b*).)	DOUBLE CONTINUOUS AS ALTERNATIVE TO STAGGERED INTERMITTENT.
	Type 1.	Type 2.	Type 3.
Inches.	Inches.	Inches.	Inches.
·20	·22	·18	·18
·30	·26	·20	·18
·40	·30	·24	·18
·50	·34	·28	·22
·60	·38	·32	·26
·70	·42	·36	
·80	·46	·40	

NOTES.—TABLE 1.

(*a*) Leg lengths for intermediate thicknesses to be obtained by direct interpolation.

(*b*) Minimum leg length of fillet weld to be ·18 inch.

CARGO AND PASSENGER SHIPS.

TABLE 2.

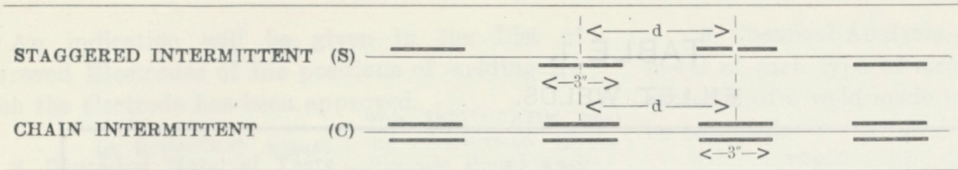
TEE JOINTS.

DOUBLE CONTINUOUS FILLET WELDS.	TYPE OF WELDS. (*See* Table 1.)
Boundaries of Watertight Bulkheads, Tunnels and Flats	2
„ Watertight and Oiltight Floors in Double Bottoms ...	1
„ Peak, Deep Water Ballast and Oil Fuel Tank Bulkheads at Bottom and Bilge	1
„ Peak, Deep Water Ballast and Oil Fuel Tank Bulkheads at Sides and Deck	2
Side Frame Brackets to Margin Plate	2
„ „ „ „ „ in Panting Area	1
Floors in Double Bottom to Margin Plate	2
„ „ „ „ „ in Panting Area	1
Centre Girder to Keel and Inner Bottom if Watertight	2
Vertical Margin Plate to Shell	2
Deck Girder Brackets to Bulkheads	2
Floors in Single Bottom to Continuous Centre Keelson	1

TABLE 3.

SPACING OF INTERMITTENT FILLET WELDS. ALL WELDS OF TYPE 1, TABLE 1.

For alternative arrangements see Section 3, clause 4 (*c*) *and* (*d*).



	S or C	Distance (d) Centre to Centre.
		Inches.
Side Framing.		
Side Frames to Shell, spacing not exceeding 30 inches	S	7
" " " spacing exceeding 30 inches	S	6
" " " in Peaks, Deep Water Ballast and Oil Fuel Tanks	S	5½
" " " in Panting Area	S	5½
Double Bottoms.		
Centre Girder to Keel	C	5
" " Inner Bottom in Engine Space and under Thrust Seating	C	6
" " " " elsewhere	C	7
Floors to Shell, spacing not exceeding 33 inches	S	7
" " spacing exceeding 33 inches	S	6
" " forward of ¼L amidships	C	5½
Floors to Inner Bottom under Engines and Thrust Seating	C	6
" " " elsewhere	S	7
Floors to Centre Girder in Engine Space, Thrust Recess, and at Boiler Bearers	C	5
" " " elsewhere	S	5
Intercostals to Shell	S	6
" Inner Bottom under Engines and Thrust Seating	C	6
" " " elsewhere	S	7
" Floors	S	7
Bracket Floors to Frames and Reverse Frames	S	5
Single Bottoms.		
Floors to Shell	S	7
" " in Peaks	S	5
" " forward of ¼L amidships	C	5½
Centre Keelson to Keel	C	5
Side Keelson to Shell	S	6
Keelsons to Top Member in Engine Room	C	5½
" " " elsewhere	S	6
Bulkheads.		
Stiffeners to Watertight Bulkheads	S	7
" " Non-Watertight Bulkheads	S	8
Stiffener Brackets	S	5
Deep Water Ballast and Oil Fuel Tanks.		
Horizontal Girders to Shell or Bulkheads	S	4½
" " " " in way of Brackets	C	4½
" " to Face Plates	S	6
Girder Brackets, where overlapped	C	4½
Vertical Stiffeners	S	6
Stiffener Brackets	S	5
Beams.		
Where on every Frame	S	7
" " " " at Watertight and Oiltight Flats	S	6
" " alternate Frames	S	6
Beam Knees	S	4
Deck Girders.		
Webs to Deck	S	5
" Face Plates	S	7
Web Frames.		
Webs to Shell	S	5
" Face Plates	S	7
Brackets to Webs, where overlapped	C	4½
Hatchways.		
Webs of Hatch Beams to Face Plates	S	7

NOTE.—For Fillet Welded Attachments in Petroleum Tankers *see* Table 76, Rules for Petroleum Tankers.

TABLES

OF

SCANTLINGS AND EQUIPMENT

FOR

STEEL SHIPS

LIST OF TABLES.

Table		Page
1	Bar Keels and Stems...	77
2	Sternframes with Apertures...	78
3	Sternframes of Twin Screw Ships ...	79
4	Floors in Single Bottoms	80
5	Keelsons in Single Bottoms	81
6	Double Bottoms	82
7	Bracket Floors...	84
8	Details of Bracket Floors	85
9	Stiffeners to Watertight Floors	86
10	Bottom Longitudinals...	87
11	Attachment of Tank Side Brackets to Margin Plate and Frames	88
12	Main Framing	92
13	'Tween Deck Framing...	98
14	Shell Plating...	100
15	Beams in Peaks Below Lowest Deck ...	102
16	Stringers in Panting Region	103
17	Ice Strengthening: Intermediate Frames	103
18	Topside Scantlings	104
19	Stringer Angles on Strength Decks ...	109
20	Lower Decks	110
21	Short Superstructures	112
22	End Bulkheads of Superstructures ...	114
23	Deckhouses	115
24	Beams at Weather Decks	118
25	Beams at Cargo and Accommodation Decks	120
26	Longitudinals at Weather Decks... ...	122
27	Longitudinals at Cargo and Accommodation Decks	123
28	Beam Knees and End Brackets of Deck Longitudinals	124
29	Deck Girders	126
30	Deck Runners	131
31	Pillars	132
32	Bulkhead Plating	135
33	Bulkhead Stiffeners—Bracketed	136
34	Bulkhead Stiffeners—Lugged	140
35	Bulkhead Stiffeners in Tugs	143
36	End Attachments for Stiffeners	143
37	Tunnel Plating	144
38	Tunnel Stiffeners	145
39	Stiffeners to Non-Watertight Bulkheads	146
40	Stiffeners on Boundary Bulkheads of Deep Tanks, Peak Tanks and Oil Fuel Bunkers	148
41	Horizontal Girders in Oil Fuel Bunkers	150
42	Exposed Machinery Casings on Upper or Superstructure Decks	151
43	Hatchway Beams	152
44	Diameter of Rudder Heads	154
45	Single Plate Rudders	155
46	Double Plate Rudders	156
47	Rudder Pintles	157
48	Couplings of Rudder Heads	158
49	Steering Chains, Rods, Quadrants and Tillers	159
50	Bolts for Bolted Tillers and Quadrants	160
51	Masts and Derrick Posts	161
52	Riveting	162
53	Equipment	170
54	Equipment for Tugs	172
55	Renewal of Chain Cables when Worn ...	173
56	Geometrical Properties of Sections ...	174

The scantlings of rolled sections are based on the British Standards as revised in 1924; alternative sections will be considered by the Committee.

TABLE 1

BAR KEELS AND STEMS.

LENGTH L	BAR KEELS.	STEMS. AREA	
Feet	Inches.	Inches.	
100	6×1	5×1 5.0	
125	$6\frac{1}{2} \times 1\frac{1}{4}$	$5\frac{1}{4} \times 1\frac{1}{8}$ 5.91	
150	$7 \times 1\frac{1}{2}$	$5\frac{1}{2} \times 1\frac{1}{4}$ 6.87	
175	$7\frac{1}{4} \times 1\frac{3}{4}$	$5\frac{3}{4} \times 1\frac{1}{2}$ 8.62	1.75
200	$7\frac{1}{2} \times 2$	$6 \times 1\frac{5}{8}$ 9.75	
225	$8 \times 2\frac{1}{8}$	$6\frac{1}{2} \times 1\frac{3}{4}$ 11.37	
250	$8\frac{1}{4} \times 2\frac{1}{4}$	$7 \times 1\frac{7}{8}$ 13.12	1.75
275	$8\frac{1}{2} \times 2\frac{3}{8}$	$7\frac{1}{2} \times 2$ 15.0	
300	$9 \times 2\frac{1}{2}$	$8 \times 2\frac{1}{8}$ 17.0	
325	$9\frac{1}{2} \times 2\frac{5}{8}$	$8\frac{1}{4} \times 2\frac{1}{4}$ 18.56	
350	$10 \times 2\frac{3}{4}$	$8\frac{1}{2} \times 2\frac{3}{8}$ 20.19	
375		$8\frac{3}{4} \times 2\frac{1}{2}$ 21.87	
400		$9 \times 2\frac{5}{8}$ 23.62	
425		$9\frac{1}{2} \times 2\frac{3}{4}$ 26.12	
450		$10 \times 2\frac{7}{8}$ 28.75	2.62
475		$10\frac{1}{2} \times 3$ 31.50	
500		11×3 33.0	
525		$11\frac{1}{4} \times 3$ 33.75	
550		$11\frac{1}{2} \times 3\frac{1}{8}$ 35.94	
575		$11\frac{3}{4} \times 3\frac{1}{4}$ 38.19	
600		$12 \times 3\frac{3}{8}$ 40.5	
625		$12 \times 3\frac{1}{2}$ 42.0	
650		$12 \times 3\frac{3}{4}$ 45.0	

$I/y = \frac{1.25 \times W^3}{6}$

$= .2083 \times W^3$

TABLE 2 STERNFRAMES WITH APERTURES.

4 to be taken as minimum (J.M.M. 5/9/31)

LENGTH L	WIDTH AND THICKNESS. SOLID. WIDTH. Rectangular. I/y	SOLID. WIDTH. Streamlined. W	CASTING. WIDTH. W	CASTING. THICKNESS. T_1 4	CASTING. THICKNESS. T_2 4	BUILT. WIDTH. W	BUILT. THICKNESS 4
1	2	3	4	5	6	7	8
Feet.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
100	2·5 (3·25)						
120	2·9 (5·1)						
140	3·3 (7·5)						
160	3·7 (10·6)						
180	4·1 (14·35)						
200	4·5 (19·0)	6·0	8·0	¾	1¼	10·0	·80
220	4·9 (24·5)	6·5	8·4	⅞	1⅜	10·4	·80
240	5·3 (31·0)	7·0	8·8	1	1½	10·8	·85
260	5·7 (38·6)	7·5	9·2	1⅛	1⅝	11·2	·85
280	6·1 (47·3)	8·0	9·5	1⅛	1⅝	11·6	·90
300	6·5 (57·3)	8·4	9·8	1¼	1¾	12·0	·90
320	6·9 (68·4)	8·8	10·1	1¼	1¾	12·4	·95
340	7·3 (81·0)	9·1	10·4	1⅜	1⅞	12·8	1·00
360	7·6 (91·5)	9·4	10·7	1⅜	2	13·2	1·05
380	7·9 (102·7)	9·7	11·0	1½	2⅛	13·6	1·10
400	8·2 (115·0)	10·0	11·3	1½	2¼	14·0	1·15
420	8·5 (128·0)	10·2	11·6	1⅝	2⅜	14·4	1·20
440	8·7 (137·2)	10·4	11·9	1⅝	2⅜	14·8	1·25
460	8·9 (146·8)	10·6	12·1	1¾	2½	15·2	1·25
480	9·1 (157·0)	10·8	12·3	1¾	2½	15·6	1·30
500	9·3 (167·5)	11·0	12·5	1¾	2½	16·0	1·30
520	9·5 (178·8)	11·2	12·7	1⅞	2½	16·4	1·35
540	9·7 (190·0)	11·4	13·0	1⅞	2½	16·8	1·35

THICKNESS OF BOSS

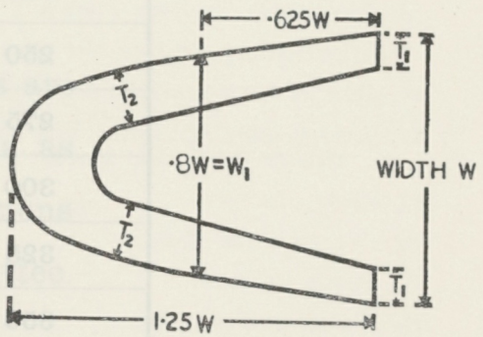
1·50 1·74 1·98 2·22 2·46 2·70 2·94 3·18 3·42 3·66 3·90 4·14 4·38 4·56 4·74 4·92 5·10 5·22 5·34 5·46 5·58 5·70 5·82

NOTES.—TABLE 2.

1. The dimensions given in the Table apply to both propeller post and rudder post.

2. The fore and aft dimension of the section is to be 25 per cent greater than its width as given in Cols. 2, 3, 4 and 7 but is not to be less than 5 inches.

3. The width W given in Cols. 3, 4 and 7 for streamlined solid, cast or built sternframes is the extreme width. The width W_1 at half the fore and aft dimension of the section is assumed to be 80 per cent of the extreme width. (See sketch.)



Where the section of sternframe adopted differs from that given above an equivalent section modulus is to be obtained.

4. The sole piece in way of the aperture is to be extended in an athwartship direction to a width 50 per cent greater than that given in Col. 2 ; the vertical dimension is to be equal to the width in Col. 2. If a rudder post is not fitted the scantlings of the sole piece will be specially considered. (104) MINIMUM WIDTH OF SOLE PIECE TO BE 5"

5. The boss of the propeller post is to have a finished thickness of metal round the bore equal to 60 per cent of the width given in Col. 2.

6. For scantlings of gudgeons *see* **Section 3, clause** 5(e).

UPPER PART OF RUDDER POST MAY BE REDUCED AS PERMITTED BY 1947-8 RULES, i.e. SECTIONAL AREA AT HEAD MAY BE 50% OF THAT GIVEN IN TABLE. (L.O. 3/6/50).

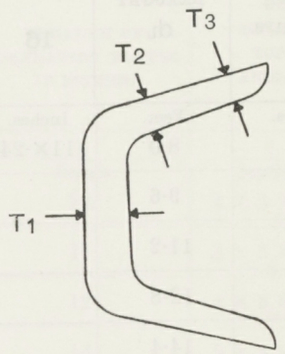
4 I/y OF SOLEPIECE $= \frac{2.25 W^3}{6} = .375 W^3$

$= I/y$ OF STERNPOST $\times \frac{.375}{.2083}$

$= I/y$ " " $\times 1.8$

STERNFRAMES OF TWIN SCREW SHIPS. TABLE 3

LENGTH L	SOLID.	CASTING.		
	WIDTH.	THICKNESS.		
		T_1	T_2	T_3
Feet.	Inches.	Inches.	Inches.	Inches.
160	1·6			
180	1·8			
200	2·0			
220	2·2	$1\frac{1}{4}$	1	$\frac{3}{4}$
240	2·4	$1\frac{1}{4}$	1	$\frac{3}{4}$
260	2·6	$1\frac{1}{4}$	1	$\frac{3}{4}$
280	2·8	$1\frac{1}{2}$	1	$\frac{3}{4}$
300	3·0	$1\frac{1}{2}$	$1\frac{1}{4}$	1
320		$1\frac{3}{4}$	$1\frac{1}{4}$	1
340		$1\frac{3}{4}$	$1\frac{1}{4}$	1
360		2	$1\frac{1}{4}$	1
380		2	$1\frac{1}{2}$	$1\frac{1}{4}$
400		$2\frac{1}{4}$	$1\frac{1}{2}$	$1\frac{1}{4}$
420		$2\frac{1}{4}$	$1\frac{3}{4}$	$1\frac{1}{4}$
440		$2\frac{1}{2}$	$1\frac{3}{4}$	$1\frac{1}{4}$
460		$2\frac{1}{2}$	$1\frac{3}{4}$	$1\frac{1}{2}$
480		$2\frac{3}{4}$	2	$1\frac{1}{2}$
500		$2\frac{3}{4}$	2	$1\frac{1}{2}$
520		3	2	$1\frac{1}{2}$
540		$3\frac{1}{4}$	2	$1\frac{1}{2}$
560		$3\frac{1}{4}$	$2\frac{1}{4}$	$1\frac{3}{4}$
580		$3\frac{1}{2}$	$2\frac{1}{4}$	$1\frac{3}{4}$
600		$3\frac{3}{4}$	$2\frac{1}{2}$	$1\frac{3}{4}$
620		$3\frac{3}{4}$	$2\frac{1}{2}$	$1\frac{3}{4}$
640		4	$2\frac{3}{4}$	$1\frac{3}{4}$



NOTES.—TABLE 3.

1. Fore and aft dimensions of solid sternposts are to be three times the width.

2. The side flanges of cast steel sternposts are to have dimensions sufficient to take the shell connection.

TABLE 4 FLOORS IN SINGLE BOTTOMS.

DEPTH D	FRAME SPACING AMIDSHIPS.	BASIC DRAUGHT d_b	BREADTH B FEET.									REVERSED FRAMES.
			16	20	24	28	32	36	40	44	48	
Feet.	Inches.	Feet.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
10	21	8·0	11×·24	12×·26	13×·26	15×·28	16×·30	17×·32	18×·34			3 × 2½×·30
12	21½	9·6		13×·26	14×·26	16×·28	18×·30	20×·32	22×·34	24×·36	26×·38	3 × 3 × ·34
14	22	11·2			15×·28	17×·30	19×·32	21×·34	23×·36	25×·38	27×·40	3½×3 × ·38
16	22½	12·8				18×·30	20×·32	22×·34	24×·36	26×·38	28×·40	4 × 3 × ·40
18	23	14·4					21×·34	23×·36	25×·38	27×·40	29×·42	5 × 3 × ·44
20	23½	16·0						24×·36	26×·38	28×·40	30×·42	5 × 3 × ·48
22	24	17·6							27×·38	29×·40	31×·42	6 × 3 × ·50
24	25	19·2							28×·40	30×·40	32×·42	6 × 3 × ·56

NOTES.—TABLE 4.

1. **Corrections.**

For Draught.

If d is $\begin{matrix}\text{greater}\\\text{less}\end{matrix}$ than d_b depth of floors is to be $\begin{matrix}\text{increased}\\\text{reduced}\end{matrix}$ at the rate of half an inch per foot of difference.

For Frame Spacing.

If the spacing amidships is $\begin{matrix}\text{greater}\\\text{less}\end{matrix}$ than that given in the Table the thickness of the floors and of the reversed frames is to be $\begin{matrix}\text{increased}\\\text{reduced}\end{matrix}$ at the rate of ·01 inch and ·02 inch respectively for every two inches of difference.

2. **Increases in Machinery Spaces.**—In the Engine Room the floors are to be increased ·04 inch and in the Boiler Room the floors and the reversed frames are to be increased ·10 inch beyond the thicknesses given in the Table.

KEELSONS IN SINGLE BOTTOMS. TABLE 5

LENGTH L	CENTRE KEELSONS.						SIDE KEELSONS.	
	PLATE KEEL ANGLES.		DOUBLE TOP ANGLES.	THICKNESS OF VERTICAL PLATES AND FOUNDATION PLATES IF FITTED.		BREADTH OF FOUNDATION PLATES IF FITTED.	SINGLE TOP ANGLE.	THICKNESS OF INTERCOSTAL PLATE.
	FOR ·4L AMIDSHIPS.	THICKNESS FOR ·1L FROM ENDS.	THROUGHOUT.	FOR ·4L AMIDSHIPS.	THICKNESS FOR ·1L FROM ENDS.			
1	2	3	4	5	6	7	8	9
Feet.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
100	3 × 3 × ·26	·26	3 × 3 × ·26	·30	·26	10	4 × 3 × ·28	·24
140	3 × 3 × ·32	·30	$3\frac{1}{2}$ × 3 × ·30	·34	·28	11	4 × 3 × ·30	·26
180	3 × 3 × ·36	·34	4 × 3 × ·32	·38	·32	12	4 × 3 × ·34	·30
220	$3\frac{1}{2}$ × $3\frac{1}{2}$ × ·40	·38	5 × 3 × ·32	·40	·34	14	5 × 3 × ·34	·32
260	$3\frac{1}{2}$ × $3\frac{1}{2}$ × ·42	·40	5 × 3 × ·38	·42	·36	16	5 × 3 × ·36	·36
300	$3\frac{1}{2}$ × $3\frac{1}{2}$ × ·44	·42	6 × $3\frac{1}{2}$ × ·40	·46	·38	18	5 × 3 × ·40	·38

KEELSONS IN TUGS.

LENGTH L	CENTRE KEELSON ON TOP OF FLOORS WITH BAR KEEL.		SIDE KEELSON ON TOP OF FLOORS.
	SINGLE CHANNEL.	DOUBLE BULB ANGLES.	SINGLE ANGLE.
Feet.	Inches.	Inches. (TOTAL)	Inches.
100	8 × $3\frac{1}{2}$ × $3\frac{1}{2}$ × ·40	5 × 3 × ·38	5 × 4 × ·36
120	9 × $3\frac{1}{2}$ × $3\frac{1}{2}$ × ·44	5 × 3 × ·46	5 × 4 × ·38
140	10 × $3\frac{1}{2}$ × $3\frac{1}{2}$ × ·48	6 × 3 × ·42	5 × 4 × ·40
160	12 × $3\frac{1}{2}$ × $3\frac{1}{2}$ × ·48	6 × 3 × ·48	5 × 4 × ·44

ASSUMED ·48/·50

NOTES.—TABLE 5.

In Boiler Rooms the thickness of the centre and side keelsons, floors and angles not covered by cement is to be increased by ·10 inch.

TABLE 6 — DOUBLE BOTTOMS.

LENGTH L	FRAME SPACING AMIDSHIPS.	CENTRE GIRDER.					MARGIN PLATE.		FLOOR PLATES, GIRDERS AND BRACKETS INSIDE TANK.		
				THICKNESS.			THICKNESS.		THICKNESS.		
		BASIC DRAUGHT. d_b	HEIGHT ABOVE BASE LINE.	FOR ·4L AMIDSHIPS.	FOR ·1L FROM ENDS.	IN BOILER ROOM.	IN HOLDS AND ENGINE ROOM.	IN BOILER ROOM.	FLOORS IN HOLDS AND ENGINE ROOM. SIDE GIRDERS IN ENGINE ROOM.	FLOORS AND SIDE GIRDERS IN BOILER ROOM.	SIDE GIRDERS IN HOLDS.
1	2	3	4	5	6	7	8	9	10	11	12
Feet.	Inches.	Feet.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
140	22	8·4	26	·32	·26	·42	·28	·38	·26	·36	·26
160	22½	9·6	26	·35	·29	·45	·31	·41	·27	·37	·26
180	23	10·8	27	·37	·31	·47	·33	·43	·28	·38	·27
200	23½	12·0	28	·39	·33	·49	·35	·45	·29	·39	·27
220	24	13·2	29	·40	·34	·50	·37	·47	·30	·40	·28
240	24½	14·4	30	·41	·35	·51	·39	·49	·31	·41	·29
260	25	15·6	31	·42	·36	·52	·40	·50	·32	·42	·30
280	25½	16·8	32	·44	·37	·54	·41	·51	·33	·43	·31
300	26	18·0	34	·45	·38	·55	·42	·52	·34	·44	·32
320	26½	19·2	35	·46	·39	·56	·43	·53	·35	·45	·33
340	27	20·4	37	·48	·40	·57	·44	·54	·36	·46	·34
360	27½	21·6	38	·49	·41	·58	·46	·55	·37	·47	·34
380	28	22·8	40	·50	·42	·59	·47	·56	·38	·48	·35
400	28½	24·0	42	·51	·43	·60	·49	·57	·39	·49	·36
420	29	25·2	43	·52	·44	·61	·50	·58	·40	·50	·36
440	29½	26·4	45	·53	·45	·62	·52	·59	·41	·51	·37
460	30	27·6	46	·54	·46	·62	·53	·60	·42	·52	·38
480	30½	28·8	48	·55	·47	·63	·55	·62	·43	·53	·39
500	31	30·0	49	·56	·48	·64	·56	·63	·44	·54	·40
520	31½	30·0	49	·57	·49	·65	·58	·65	·45	·55	·41
540	32	30·0	50	·58	·50	·66	·60	·66	·46	·55	·42
560	32½	30·0	51	·59	·51	·66	·62	·68	·47	·56	·43
580	33	30·0	51	·60	·52	·67	·64	·69	·48	·56	·44
600	33½	30·0	52	·61	·53	·67	·66	·71	·49	·57	·44
620	34	30·0	52	·62	·54	·68	·67	·72	·50	·57	·45
640	34½	30·0	53	·63	·55	·68	·69	·74	·51	·58	·46

NOTES.—TABLE 6.

(8) HEIGHT OF CR. GIRDER MAY BE REDUCED FOR EXCESS DEPTH OF MARGIN PLATE.

1. **Corrections.**

For Draught.

If d is $\frac{\text{greater}}{\text{less}}$ than d_b the height of the centre girder to be $\frac{\text{increased}}{\text{reduced}}$ at the rate of half an inch for each foot of difference.

For Frame Spacing.

(33) SIDE GIRDERS NOT CORRECTED FOR FRAME SPACING.

If the spacing amidships is $\frac{\text{greater}}{\text{less}}$ than that given in Col. 2 the thickness of the floor and bracket plates, margin plate and inner bottom plating to be $\frac{\text{increased}}{\text{reduced}}$ at the rate of ·01 inch for every two inches of difference.

NOT CR & SIDE GIRDERS. FOR T.S BKT SEE TABLE 11.

WITH LONGL. FRAMING, CORRECTION BASED ON SPACING OF LONGLS. GIVEN IN TABLE 10.

The thickness of the inner bottom plating in the engine and boiler rooms and of the middle line strake throughout should not be corrected for frame spacing but is not to be less than the thickness derived from Col. 16 after correction.

The thickness of watertight floors is to be ·08 inch greater than the thickness given in Col. 10, but need not exceed ·54 inch. NOT TO BE CORRECTED FOR SPACING.

DOUBLE BOTTOMS. TABLE 6

BREADTH.	INNER BOTTOM PLATING. MIDDLE LINE STRAKE EXCEPT IN BOILER ROOM. THICKNESS. FOR ·4L AMIDSHIPS.	FOR ·1L FROM ENDS.	REMAINDER. THICKNESS. IN HOLDS. FOR ·4L AMIDSHIPS.	FOR ·1L FROM ENDS.	IN ENGINE ROOM.	IN BOILER ROOM INCLUDING MIDDLE LINE STRAKE.	ANGLE CONNECTIONS. ANGLES CONNECTING CENTRE GIRDER TO FLAT PLATE KEEL. FOR ·4L AMIDSHIPS.	THICKNESS FOR ·1L FROM ENDS.	ANGLES CONNECTING CENTRE GIRDER TO INNER BOTTOM. FOR ·4L AMIDSHIPS.	THICKNESS FOR ·1L FROM ENDS.	ANGLES CONNECTING MARGIN PLATE TO SHELL PLATING.	LENGTH L
13	14	15	16	17	18	19	20	21	22	23	24	25
Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Feet.
38	·28	·26	·26	·26	·30	·42	3 × 3 × ·32	·30	$2\frac{1}{2}\times2\frac{1}{2}\times$·28	·28	3 × 3 × ·30	140
39	·30	·28	·28	·27	·32	·44	3 × 3 × ·34	·32	$2\frac{1}{2}\times2\frac{1}{2}\times$·29	·29	3 × 3 × ·32	160
40	·32	·30	·30	·28	·34	·45	3 × 3 × ·36	·34	3 × 3 × ·30	·30	3 × 3 × ·34	180
41	·34	·31	·31	·29	·36	·47	3 × 3 × ·38	·36	3 × 3 × ·32	·31	3 × 3 × ·36	200
42	·36	·32	·32	·30	·38	·48	$3\frac{1}{2}\times3\frac{1}{2}\times$·40	·38	3 × 3 × ·34	·32	3 × 3 × ·38	220
43	·38	·33	·33	·31	·39	·49	$3\frac{1}{2}\times3\frac{1}{2}\times$·41	·39	3 × 3 × ·36	·34	3 × 3 × ·40	240
44	·40	·34	·34	·32	·40	·50	$3\frac{1}{2}\times3\frac{1}{2}\times$·42	·40	3 × 3 × ·38	·36	3 × 3 × ·42	260
45	·41	·35	·35	·32	·41	·51	$3\frac{1}{2}\times3\frac{1}{2}\times$·43	·41	3 × 3 × ·39	·37	3 × 3 × ·44	280
46	·42	·36	·36	·33	·42	·52	$3\frac{1}{2}\times3\frac{1}{2}\times$·44	·42	3 × 3 × ·40	·38	$3\frac{1}{2}\times3\frac{1}{2}\times$·44	300
47	·44	·37	·37	·33	·44	·53	$3\frac{1}{2}\times3\frac{1}{2}\times$·45	·43	3 × 3 × ·41	·39	$3\frac{1}{2}\times3\frac{1}{2}\times$·45	320
48	·45	·38	·38	·34	·45	·54	$3\frac{1}{2}\times3\frac{1}{2}\times$·46	·44	3 × 3 × ·42	·40	$3\frac{1}{2}\times3\frac{1}{2}\times$·46	340
49	·47	·39	·39	·35	·47	·55	$3\frac{1}{2}\times3\frac{1}{2}\times$·47	·45	3 × 3 × ·43	·41	$3\frac{1}{2}\times3\frac{1}{2}\times$·47	360
50	·48	·40	·40	·36	·48	·56	$3\frac{1}{2}\times3\frac{1}{2}\times$·48	·46	3 × 3 × ·44	·42	$3\frac{1}{2}\times3\frac{1}{2}\times$·48	380
51	·49	·41	·41	·37	·49	·56	$3\frac{1}{2}\times3\frac{1}{2}\times$·49	·47	$3\frac{1}{2}\times3\frac{1}{2}\times$·45	·42	$3\frac{1}{2}\times3\frac{1}{2}\times$·49	400
52	·50	·42	·42	·38	·50	·57	$3\frac{1}{2}\times3\frac{1}{2}\times$·50	·48	$3\frac{1}{2}\times3\frac{1}{2}\times$·46	·42	$3\frac{1}{2}\times3\frac{1}{2}\times$·50	420
53	·51	·43	·43	·39	·51	·57	5 × 5 × ·52	·49	$3\frac{1}{2}\times3\frac{1}{2}\times$·47	·43	$3\frac{1}{2}\times3\frac{1}{2}\times$·52	440
54	·52	·44	·44	·40	·52	·58	5 × 5 × ·54	·50	$3\frac{1}{2}\times3\frac{1}{2}\times$·48	·44	$3\frac{1}{2}\times3\frac{1}{2}\times$·54	460
55	·54	·46	·46	·42	·54	·59	5 × 5 × ·55	·51	$3\frac{1}{2}\times3\frac{1}{2}\times$·49	·45	$3\frac{1}{2}\times3\frac{1}{2}\times$·55	480
56	·55	·47	·47	·43	·55	·60	5 × 5 × ·56	·52	$3\frac{1}{2}\times3\frac{1}{2}\times$·50	·46	$3\frac{1}{2}\times3\frac{1}{2}\times$·56	500
57	·57	·49	·49	·45	·57	·61	5 × 5 × ·58	·53	$3\frac{1}{2}\times3\frac{1}{2}\times$·52	·47	$3\frac{1}{2}\times3\frac{1}{2}\times$·56	520
58	·58	·50	·50	·46	·58	·62	5 × 5 × ·60	·54	$3\frac{1}{2}\times3\frac{1}{2}\times$·54	·48	$3\frac{1}{2}\times3\frac{1}{2}\times$·56	540
59	·60	·52	·51	·47	·60	·63	5 × 5 × ·61	·55	$3\frac{1}{2}\times3\frac{1}{2}\times$·55	·49	$3\frac{1}{2}\times3\frac{1}{2}\times$·56	560
60	·61	·53	·52	·48	·61	·64	5 × 5 × ·62	·56	$3\frac{1}{2}\times3\frac{1}{2}\times$·56	·50	$3\frac{1}{2}\times3\frac{1}{2}\times$·56	580
61	·63	·55	·53	·49	·63	·65	5 × 5 × ·64	·58	$3\frac{1}{2}\times3\frac{1}{2}\times$·56	·51	$3\frac{1}{2}\times3\frac{1}{2}\times$·56	600
62	·64	·56	·54	·50	·64	·66	5 × 5 × ·66	·60	$3\frac{1}{2}\times3\frac{1}{2}\times$·56	·52	$3\frac{1}{2}\times3\frac{1}{2}\times$·56	620
63	·66	·58	·55	·51	·66	·67	5 × 5 × ·68	·62	$3\frac{1}{2}\times3\frac{1}{2}\times$·56	·54	$3\frac{1}{2}\times3\frac{1}{2}\times$·56	640

NOTES.—TABLE 6 (*continued*).

2. **Depth of Margin Plate** is not to be less than 80 per cent of the depth of centre girder corrected by Note 1, where the length of the ship does not exceed 350 feet or 85 per cent where the length is 400 feet and above, with intermediate values in proportion. At the after end the depth may be reduced to 85 per cent of the depth amidships.

MIDSHIP DEPTH OF MARGIN TO BE MAINTAINED FOR ·4L.

3. **Thickness of Connecting Angles not given in Table.**—The thickness of the vertical angles connecting intercostal girders to floors is not to be less than that of the intercostal plate. The thickness of the frames, reversed frames and other connecting angles is not to be less than the thickness of the floors, CORRECTED WHERE NECESSARY FOR SPACING.

TOP & BOTTOM BARS ON SIDE GIRDERS NOT TO BE CORRECTED FOR SPACING.

4. **Width of Faying Flanges.** For width of faying flanges for all angles, unless specified in the Table, *see* **Section 31, clause 1** (*b*).

5. **In Boiler Rooms** angles not covered by cement are to be increased by ·10 inch in thickness.

6. **Oil Fuel.** For thickness of inner bottom plating when oil fuel is carried in the double bottom, *see* **Section 20, clause 10** (*b*).

ANGLES CONNECTING T.S.B. TO MARGIN, SAME THICKNESS AS FRAME BRACKET (SEE TABLE 11, NOTE 3)

TABLE 7 — BRACKET FLOORS.

DEPTH D	FRAME SPACING AMIDSHIPS.	BASIC DRAUGHT d_b	CORRECTION TO MODULUS PER 1 FT. DIFFERENCE BETWEEN d and d_b	UNSUPPORTED SPAN. FEET. 3	4	5	6	7	8	
Feet.	Inches.	Feet.	Per Cent.	INCHES — Modulus – Inches³						
12	21½	9·6	10·4	$3\frac{1}{2}\times2\frac{1}{2}\times\cdot36$ 1·55	4 × 3 × ·47 2·60	5 × 3 × ·40 3·30				ANGLES
14	22	11·2	9·0	4 × 3 × ·34 1·90	5 × 3 × ·38 3·15	6 × 3 × ·33 4·00				
16	22½	12·8	7·8	4 × 3 × ·40 2·20	5 × 3 × ·44 3·65	5 × 3 × ·35 4·65	5 × 3 × ·40 5·15			
18	23	14·4	7·0	4 × 3 × ·46 2·50	6 × 3 × ·35 4·20	5 × 3 × ·42 5·35	$5\frac{1}{2}\times3\times\cdot37$ 5·95	6 × 3 × ·34 6·80	6 × 3 × ·46 8·45	
20	23½	16·0	6·2	5 × 3 × ·34 2·85	5 × 3 × ·36 4·75	$5\frac{1}{2}\times3\times\cdot38$ 6·05	6 × 3 × ·34 6·80	6 × 3 × ·40 7·65	7 × 3 × ·34 9·60	
22	24	17·6	5·7	5 × 3 × ·39 3·25	5 × 3 × ·42 5·35	6 × 3½ × ·34 6·85	6 × 3½ × ·39 7·55	6 × 3½ × ·48 8·80	7 × 3½ × ·41 10·80	
24	25	19·2	5·2	5 × 3 × ·44 3·65	$5\frac{1}{2}\times3\times\cdot39$ 6·15	6 × 3½ × ·40 7·65	6 × 3½ × ·46 8·50	7 × 3½ × ·35 9·80	7 × 3½ × ·49 12·25	
26	26	20·8	4·8	6 × 3 × ·35 4·20	6 × 3 × ·34 6·80	6 × 3½ × ·47 8·65	7 × 3½ × ·34 9·65	7 × 3½ × ·43 11·15	8 × 3½ × ·38 13·85	
28	27	22·4	4·5	5 × 3 × ·35 4·65	6 × 3 × ·40 7·65	7 × 3½ × ·34 9·65	7 × 3½ × ·41 10·80	7 × 3½ × ·50 12·45	8 × 3½ × ·44 15·25	
30	28	24·0	4·2	5 × 3 × ·40 5·15	6 × 3 × ·46 8·45	7 × 3½ × ·41 10·80	7 × 3½ × ·48 12·05	8 × 3½ × ·38 13·85	8 × 3½ × ·52 17·15	
32	29	25·6	3·9	$5\frac{1}{2}\times3\times\cdot35$ 5·70	9·40	7 × 3½ × ·47 11·90	8 × 3½ × ·35 13·25	8 × 3½ × ·44 15·25	9 × 3½ × ·40 18·90	
34	30	27·2	3·7	$5\frac{1}{2}\times3\times\cdot40$ 6·25	7 × 3 × ·38 10·25	13·10	8 × 3½ × ·41 14·60	8 × 3½ × ·50 16·70	9 × 3½ × ·47 20·80	
36	31	28·8	3·5	6 × 3½ × ·34 6·85	7 × 3½ × ·44 11·30	8 × 3½ × ·40 14·35	8 × 3½ × ·47 16·00	18·30	9 × 3½ × ·54 22·70	
38	32	30·0	3·3	6 × 3½ × ·38 7·40	7 × 3½ × ·49 12·25	8 × 3½ × ·45 15·50	8 × 3½ × ·54 17·60	9 × 3½ × ·43 19·65	24·40	
40	33	30·0	3·3	6 × 3½ × ·40 7·65	7 × 3½ × ·51 12·65	8 × 3½ × ·47 16·00	18·15	9 × 3½ × ·45 20·20	10 × 3½ × ·43 25·15	
42	34	30·0	3·3	6 × 3½ × ·42 7·95	12·95	8 × 3½ × ·49 16·45	9 × 3½ × ·39 18·65	9 × 3½ × ·48 21·05	10 × 3½ × ·46 26·10	
44	35	30·0	3·3	6 × 3½ × ·44 8·20	8 × 3½ × ·35 13·25	8 × 3½ × ·51 16·95	9 × 3½ × ·42 19·40	9 × 3½ × ·50 21·60	10 × 3½ × ·48 26·80	
46	36	30·0	3·3	6 × 3½ × ·46 8·50	8 × 3½ × ·37 13·65	8 × 3½ × ·53 17·40	9 × 3½ × ·44 19·90	9 × 3½ × ·52 22·20	10 × 3½ × ·50 27·40	
48	37	30·0	3·3	6 × 3½ × ·47 8·65	8 × 3½ × ·39 14·10	8 × 3½ × ·55 17·85	9 × 3½ × ·46 20·50	9 × 3½ × ·54 22·70	10 × 3½ × ·52 28·10	
50	38	30·0	3·3	6 × 3½ × ·49 8·95	8 × 3½ × ·41 14·60	18·35	9 × 3½ × ·48 21·05	9 × 3½ × ·56 23·30	10 × 3½ × ·54 28·80	BULB ANGLES

Section moduli above are given to nearest ·05.

NOTES.—TABLE 7.

1. **Scantlings.**—The bottom frames are to have scantlings determined from the Table; the modulus of the reversed frames may be 85 per cent of that of the bottom frames corrected as required below. For width of faying flanges *see* **Section 31, clause 1** (*b*).

2. **Correction to Modulus of Frames.**

For Draught.

If d is $\begin{matrix}\text{greater}\\\text{less}\end{matrix}$ than d_b, modulus to be $\begin{matrix}\text{increased}\\\text{reduced}\end{matrix}$ by the percentage given in the Table per foot of difference.

For Frame Spacing.

If the spacing amidships differs from that given in the Table, modulus to be modified in direct proportion.

3. **In Boiler Rooms**, frames, reversed frames, struts and angle connections are to be increased by ·10 inch in thickness.

4. Particulars of sections and moduli are given in **Table 56.**

DETAILS OF BRACKET FLOORS. TABLE 8

DEPTH OF FRAME.		RIVETS IN BRACKETS.		RIVETS IN EACH END OF VERTICAL BAR ON INTERCOSTAL GIRDER.		VERTICAL STRUTS BETWEEN INTERCOSTAL GIRDER AND CENTRE LINE OR MARGIN PLATE.		RIVETS IN EACH END OF VERTICAL STRUTS.	
		NUMBER.	DIAMETER.	NUMBER.	DIAMETER.			NUMBER.	DIAMETER.
1		2	3	4	5		6	7	8
Inches			Inches.		Inches.		Inches.		Inches.
$3\frac{1}{2}$ and 4	ANGLES	4	$\frac{5}{8}$	2	$\frac{5}{8}$	ANGLES	6 × 3 × ·34	2	$\frac{5}{8}$
5	ANGLES	5	$\frac{5}{8}$	2	$\frac{5}{8}$	ANGLES	6 × 3 × ·36	3	$\frac{5}{8}$
6	ANGLES	5	$\frac{3}{4}$	2	$\frac{3}{4}$	CHANNELS	7 × 3 × 3 × ·36	4	$\frac{3}{4}$
5 and $5\frac{1}{2}$	BULB ANGLES	5	$\frac{3}{4}$	2	$\frac{3}{4}$	CHANNELS	8 × 3 × 3 × ·36	4	$\frac{3}{4}$
6	BULB ANGLES	6	$\frac{3}{4}$	2	$\frac{3}{4}$	CHANNELS	8 × 3 × 3 × ·40	4	$\frac{7}{8}$
7	BULB ANGLES	7	$\frac{3}{4}$	3	$\frac{3}{4}$	CHANNELS	8 × 3 × 3 × ·40	4	$\frac{7}{8}$
8	BULB ANGLES	8	$\frac{3}{4}$	4	$\frac{3}{4}$	CHANNELS	9 × 3 × 3 × ·44	5	$\frac{7}{8}$
9	BULB ANGLES	8	$\frac{7}{8}$	4	$\frac{7}{8}$	CHANNELS	10 × 3 × 3 × ·44	6	$\frac{7}{8}$
10 and above	BULB ANGLES	9	$\frac{7}{8}$	4	$\frac{7}{8}$	CHANNELS	10 × 3 × 3 × ·50	6	$\frac{7}{8}$

NOTES.—TABLE 8.

1. **In Boiler Rooms** struts are to be increased by ·10 inch in thickness.

2. For scantlings of welded vertical struts *see* **Section 5, clause 5(c).**

TABLE 9 STIFFENERS TO WATERTIGHT FLOORS

Spaced 30 inches apart.

DEPTH OF CENTRE GIRDER.	HEIGHT OF OVERFLOW ABOVE INNER BOTTOM. FEET.						
	20	25	30	35	40	45	50
Inches.	INCHES *Modulus—Inches*^{3}						
36	$3\frac{1}{2} \times 3 \times .32$ *1·40*	$3\frac{1}{2} \times 3 \times .40$ *1·75*	$4 \times 3 \times .36$ *2·00*	$4 \times 3 \times .43$ *2·35*	$4 \times 3 \times .47$ *2·60*	$5 \times 3 \times .36$ *3·00*	$5 \times 3 \times .40$ *3·30*
42	$4 \times 3 \times .34$ *1·90*	$4 \times 3 \times .42$ *2·30*	$5 \times 3 \times .32$ *2·70*	$5 \times 3 \times .38$ *3·15*	$5 \times 3 \times .44$ *3·65*	$5 \times 3 \times .48$ *3·95*	$6 \times 3 \times .38$ *4·55*
48	$4 \times 3 \times .47$ *2·60*	$5 \times 3 \times .38$ *3·15*	$5 \times 3 \times .44$ *3·65*	$6 \times 3 \times .36$ *4·30*	$6 \times 3 \times .40$ *4·75*	$5\frac{1}{2} \times 3 \times .36$ *5·80*	$5\frac{1}{2} \times 3 \times .40$ *6·25*
54	$5 \times 3 \times .40$ *3·30*	$5 \times 3 \times .48$ *3·95*	$6 \times 3 \times .40$ *4·75*	$5\frac{1}{2} \times 3 \times .36$ *5·80*	$5\frac{1}{2} \times 3 \times .40$ *6·25*	$6 \times 3 \times .36$ *7·10*	$6 \times 3 \times .40$ *7·65*
60	$5 \times 3 \times .48$ *3·95*	$6 \times 3 \times .42$ *5·00*	$5\frac{1}{2} \times 3 \times .36$ *5·80*	$6 \times 3 \times .36$ *7·10*	$6 \times 3 \times .40$ *7·65*	$6 \times 3 \times .46$ *8·45*	$6 \times 3 \times .52$ *9·30*
66	$6 \times 3 \times .42$ *5·00*	$5\frac{1}{2} \times 3 \times .36$ *5·80*	$6 \times 3 \times .36$ *7·10*	$6 \times 3 \times .46$ *8·45*	$6 \times 3 \times .52$ *9·30*	$7 \times 3 \times .40$ *10·60*	$7 \times 3 \times .46$ *11·65*
72	$5\frac{1}{2} \times 3 \times .36$ *5·80*	$6 \times 3 \times .36$ *7·10*	$6 \times 3 \times .46$ *8·45*	$7 \times 3 \times .36$ *9·95*	$7 \times 3 \times .42$ *10·95*	$7 \times 3 \times .49$ *12·25*	$8 \times 3 \times .38$ *13·85*

ANGLES — BULB ANGLES — ANGLES — BULB ANGLES

Section moduli above are given to nearest ·05.

NOTES.—TABLE 9.

1. **In Boiler Rooms** stiffeners are to be increased by ·10 inch in thickness.

2. Particulars of sections and moduli are given in **Table 56.**

BOTTOM LONGITUDINALS. TABLE 10

LENGTH L	SPACING OF LONGITUDINALS.	BASIC DRAUGHT d_b	CORRECTION TO MODULUS PER 1 FT. DIFFERENCE BETWEEN d and d_b	UNSUPPORTED SPAN. FEET. 4	5	6	7	8
Feet.	Inches.	Feet.	Per Cent	INCHES *Modulus—Inches*^{3}				
240	$28\frac{1}{2}$	14·4	*6·9*	$5\frac{1}{2}\times 3\times{\cdot}37$ *5·95*	$6\times 3\times{\cdot}37$ *7·25*	$6\times 3\times{\cdot}46$ *8·45*	$7\times 3\times{\cdot}35$ *9·80*	$7\times 3\times{\cdot}43$ *11·15*
260	29	15·6	*6·4*	$6\times 3\times{\cdot}33$ *6·65*	$6\times 3\times{\cdot}43$ *8·05*	$6\times 3\times{\cdot}53$ *9·45*	$7\times 3\times{\cdot}42$ *10·95*	$7\times 3\times{\cdot}50$ *12·40*
280	$29\frac{1}{2}$	16·8	*6·0*	$6\times 3\times{\cdot}38$ *7·35*	$6\times 3\times{\cdot}50$ *9·00*	$7\times 3\times{\cdot}39$ *10·45*	$7\times 3\times{\cdot}48$ *12·05*	$7\times 3\times{\cdot}57$ *13·70*
300	30	18·0	*5·6*	$6\times 3\frac{1}{2}\times{\cdot}44$ *8·20*	$7\times 3\frac{1}{2}\times{\cdot}36$ *9·95*	$7\times 3\frac{1}{2}\times{\cdot}45$ *11·50*	$8\times 3\frac{1}{2}\times{\cdot}35$ *13·25*	$8\times 3\frac{1}{2}\times{\cdot}43$ *15·05*
320	$30\frac{1}{2}$	19·2	*5·2*	$6\times 3\frac{1}{2}\times{\cdot}50$ *9·05*	$7\times 3\frac{1}{2}\times{\cdot}42$ *10·95*	$7\times 3\frac{1}{2}\times{\cdot}51$ *12·65*	$8\times 3\frac{1}{2}\times{\cdot}41$ *14·60*	$8\times 3\frac{1}{2}\times{\cdot}49$ *16·45*
340	31	20·4	*4·9*	$7\times 3\frac{1}{2}\times{\cdot}37$ *10·10*	$7\times 3\frac{1}{2}\times{\cdot}48$ *12·05*	$8\times 3\frac{1}{2}\times{\cdot}38$ *13·85*	$8\times 3\frac{1}{2}\times{\cdot}46$ *15·75*	$8\times 3\frac{1}{2}\times{\cdot}55$ *17·85*
360	$31\frac{1}{2}$	21·6	*4·6*	$7\times 3\frac{1}{2}\times{\cdot}43$ *11·15*	*13·00*	$8\times 3\frac{1}{2}\times{\cdot}44$ *15·25*	$8\times 3\frac{1}{2}\times{\cdot}52$ *17·15*	$9\times 3\frac{1}{2}\times{\cdot}42$ *19·40*
380	32	22·8	*4·4*	$7\times 3\frac{1}{2}\times{\cdot}48$ *12·05*	$8\times 3\frac{1}{2}\times{\cdot}40$ *14·35*	$8\times 3\frac{1}{2}\times{\cdot}49$ *16·45*	*18·70*	$9\times 3\frac{1}{2}\times{\cdot}48$ *21·05*
400	$32\frac{1}{2}$	24·0	*4·2*	*13·20*	$8\times 3\frac{1}{2}\times{\cdot}45$ *15·50*	$8\times 3\frac{1}{2}\times{\cdot}55$ *17·85*	$9\times 3\frac{1}{2}\times{\cdot}45$ *20·20*	$9\times 3\frac{1}{2}\times{\cdot}54$ *22·70*
420	33	25·2	*4·0*	$8\times 3\frac{1}{2}\times{\cdot}40$ *14·35*	$8\times 3\frac{1}{2}\times{\cdot}50$ *16·70*	$9\times 3\frac{1}{2}\times{\cdot}41$ *19·15*	$9\times 3\frac{1}{2}\times{\cdot}51$ *21·90*	*24·45*
440	$33\frac{1}{2}$	26·4	*3·8*	$8\times 3\frac{1}{2}\times{\cdot}46$ *15·75*	$8\times 3\frac{1}{2}\times{\cdot}56$ *18·05*	$9\times 3\frac{1}{2}\times{\cdot}47$ *20·80*	$9\times 3\frac{1}{2}\times{\cdot}57$ *23·60*	$10\times 3\frac{1}{2}\times{\cdot}46$ *26·10*
460	34	27·6	*3·6*	$8\times 3\frac{1}{2}\times{\cdot}51$ *16·95*	$9\times 3\frac{1}{2}\times{\cdot}43$ *19·65*	$9\times 3\frac{1}{2}\times{\cdot}52$ *22·20*	$10\times 3\frac{1}{2}\times{\cdot}43$ *25·15*	$10\times 3\frac{1}{2}\times{\cdot}52$ *28·10*
480	$34\frac{1}{2}$	28·8	*3·4*	*18·50*	$9\times 3\frac{1}{2}\times{\cdot}48$ *21·05*	$9\times 3\frac{1}{2}\times{\cdot}59$ *24·15*	$10\times 3\frac{1}{2}\times{\cdot}49$ *27·10*	$10\times 3\frac{1}{2}\times{\cdot}58$ *30·10*
500	35	30·0	*3·3*	$9\times 3\frac{1}{2}\times{\cdot}44$ *19·90*	$9\times 3\frac{1}{2}\times{\cdot}54$ *22·70*	$10\times 3\frac{1}{2}\times{\cdot}45$ *25·80*	$10\times 3\frac{1}{2}\times{\cdot}54$ *28·80*	*32·00*

BULB ANGLES

Section moduli above are given to nearest ·05.

NOTES.—TABLE 10.

1. **Scantlings.**—The bottom longitudinals are to have scantlings determined from the Table; the modulus of the inner bottom longitudinals may be 85 per cent of that of the bottom longitudinals corrected as required below. For width of faying flanges *see* **Section 31, clause 1** (*b*).

2. **Corrections to Modulus of Bottom Longitudinals.**

For Draught.

If d is $\frac{\text{greater}}{\text{less}}$ than d_b, modulus to be $\frac{\text{increased}}{\text{reduced}}$ by the percentage given in the Table per foot of difference.

For Spacing of Longitudinals.

If the spacing amidships differs from that given in the Table, modulus to be modified in direct proportion.

3. **In Boiler Rooms,** longitudinals, struts and angle connections are to be increased by ·10 inch in thickness.

4. Particulars of sections and moduli are given in **Table 56.**

TABLE 11

(SEE CONTINUATION.)

ATTACHMENT OF TANK SIDE BRACKET

DEPTH D	FRAME SPACING AMIDSHIPS.	HEIGHT OF TANK SIDE BRACKET ABOVE BASE.	FRAME. 4 INCH ORDINARY ANGLE. THICKNESS OF TANK SIDE BRACKET AND GUSSET.	4 INCH ORDINARY ANGLE. NUMBER AND DIAMETER OF RIVETS PER FRAME SPACE. ANGLE TO MARGIN.	GUSSET.	4 FRAME CONNECTION.	5 INCH ORDINARY ANGLE. THICKNESS OF TANK SIDE BRACKET AND GUSSET.	5 INCH ORDINARY ANGLE. NUMBER AND DIAMETER OF RIVETS PER FRAME SPACE. ANGLE TO MARGIN.	GUSSET.	4 FRAME CONNECTION.	6 INCH ORDINARY ANGLE. THICKNESS OF TANK SIDE BRACKET AND GUSSET.	6 INCH ORDINARY ANGLE. NUMBER AND DIAMETER OF RIVETS PER FRAME SPACE. ANGLE TO MARGIN.	GUSSET.	4 FRAME CONNECTION.
Feet.	Inches.	Inches.	Inches.				Inches.				Inches			
10	21	28	·26	5†	—	5†								
12	21½	32	·27	5†	—	5†	·28	5†	—	5†	·29	5*	—	5†
14	22	36	·28	5†	—	5†	·29	5*	—	5†	·30	5*	—	5†
16	22½	40	·28	5*	—	5†	·29	5*	—	5*	·31	5*	—	5*
18	23	44									·32	6*	—	5*
20	23½	48									·33	6*	—	5*
22	24	52												
24	25	55												
26	26	58												
28	27	61												
30	28	64												
32	29	67												
34	30	70												
36	31	72												
38	32	74												
40	33	76												
42	34	78												
44	35	79												
46	36	81												
48	37	83												
50	38	84												

† Rivets $\frac{5}{8}$ inch diameter. * Rivets $\frac{3}{4}$ inch diameter. Remainder $\frac{7}{8}$ inch diameter.

·31 ·44 ·60.

For Notes see pages 90 & 91.

TO MARGIN PLATE AND FRAMES.

TABLE 11

(SEE CONTINUATION.)

FRAME. 1/y = 6·50 To 9·30 | 1/y = 9·45 To 12·80 | 1/y = 13·65 To 17·80 | 1/y = 18·65 To 24·15.

6 INCH BULB ANGLE. 32"-·52"				7 INCH BULB ANGLE. 33"-·52"				8 INCH BULB ANGLE. 37"-·55"				9 INCH BULB ANGLE. 39"-·59"				DEPTH D
THICKNESS OF TANK SIDE BRACKET AND GUSSET.	NUMBER AND DIAMETER OF RIVETS PER FRAME SPACE.			THICKNESS OF TANK SIDE BRACKET AND GUSSET.	NUMBER AND DIAMETER OF RIVETS PER FRAME SPACE.			THICKNESS OF TANK SIDE BRACKET AND GUSSET.	NUMBER AND DIAMETER OF RIVETS PER FRAME SPACE.			THICKNESS OF TANK SIDE BRACKET AND GUSSET.	NUMBER AND DIAMETER OF RIVETS PER FRAME SPACE.			
	ANGLE TO MARGIN.	GUSSET.	†FRAME CONNECTION.		ANGLE TO MARGIN.	GUSSET.	†FRAME CONNECTION.		ANGLE TO MARGIN.	GUSSET.	†FRAME CONNECTION.		ANGLE TO MARGIN.	GUSSET.	†FRAME CONNECTION.	
Inches.				Inches.				Inches.				Inches.				Feet. 10
																12
·31	6*	—	5*	·32	6*	-	6*	·33	6*	-	6*					14
·32	6*	—	6*	·33	6*	-	6*	·33	6*	-	6*					16
·32	6*	—	6*	·33	6*	—	6*	·34	6*	1*	6*					18
·34	6*	—	6*	·34	6*	1*	6*	·34	6*	2*	7*					20
·35	6*	1*	6*	·35	6*	2*	6*	·35	5	1	5	·36	6	2	7	22
·36	6*	1*	6*	·36	6*	2*	6*	·36	5	2	6	·38	6	3	7	24
·38	6*	2*	6*	·38	5	1	5	·38	5	2	6	·40	6	4	8	26
				·40	5	2	5	·40	6	2	6	·41	7	4	8	28
				·41	6	2	6	·41	6	3	7	·42	7	4	8	30
								·42	7	3	7	·43	7	4	8	32
								·43	7	3	7	·44	8	4	8	34
								·44	7	4	8	·44	8	5	8	36
												·45	8	6	8	38
												·46	8	6	9	40
												·47	8	7	9	42
												·47	8	7	9	44
																46
																48
																50

† Rivets $\frac{5}{8}$ inch diameter. * Rivets $\frac{3}{4}$ inch diameter. Remainder $\frac{7}{8}$ inch diameter.

† SEE NOTE (90) PAGE 91.

For Notes see pages 90 & 91.

SECT 5. PARA 9 (b). PAGE 38.

GUSSET PLATES NOT MORE THAN THREE SPACES APART: IF Nº OF RIVS REQUIRED > 6. GUSSET AT EVERY FRAME OR CONTINUOUS PLATE. NOT LESS THAN 3 RIVS IN GUSSET.

NOTE 12" L ·51 TO ·68
47·40 TO 54.15.

TABLE 11
(CONCLUDED.)

ATTACHMENT OF TANK SIDE BRACKE

DEPTH D	FRAME SPACING AMIDSHIPS.	HEIGHT OF TANK SIDE BRACKET ABOVE BASE.	10 INCH BULB ANGLE. ·42 - ·62 (1/y = 24·80 TO 31·45)				11 INCH BULB ANGLE. ·44 - ·65 (1/y = FRAME. 31·55 TO 39·80)				12 INCH BULB ANGLE. ·46 - ·64 (1/y = 39·45 TO 47·75.)			
			THICKNESS OF TANK SIDE BRACKET AND GUSSET.	NUMBER AND DIAMETER OF RIVETS PER FRAME SPACE.			THICKNESS OF TANK SIDE BRACKET AND GUSSET.	NUMBER AND DIAMETER OF RIVETS PER FRAME SPACE.			THICKNESS OF TANK SIDE BRACKET AND GUSSET.	NUMBER AND DIAMETER OF RIVETS PER FRAME SPACE.		
				ANGLE TO MARGIN.	GUSSET.	FRAME CONNECTION.		ANGLE TO MARGIN.	GUSSET.	FRAME CONNECTION.		ANGLE TO MARGIN.	GUSSET.	FRAME CONNECTION.
Feet.	Inches.	Inches	Inches.				Inches.				Inches.			
10	21	28												
12	21½	32												
14	22	36												
16	22½	40												
18	23	44												
20	23½	48												
22	24	52	·38	6	4	8								
24	25	55	·40	6	5	8								
26	26	58	·41	7	6	8	·42	7	6	8	·42	8	7	9
28	27	61	·42	7	6	8	·43	7	7	8	·43	8	8	9
30	28	64	·43	8	6	9	·44	8	7	9	·44	9	8	10
32	29	67	·44	8	6	9	·44	8	7	9	·45	9	8	10
34	30	70	·45	8	6	9	·45	8	7	9	·46	9	8	10
36	31	72	·45	8	6	9	·46	9	7	10	·47	9	8	10
38	32	74	·46	8	7	9	·47	9	7	10	·48	9	8	10
40	33	76	·47	8	7	10	·47	9	8	11	·48	9	9	11
42	34	78	·48	8	8	10	·48	9	9	11	·49	10	9	11
44	35	79	·48	9	8	10	·48	9	9	11	·49	10	9	12
46	36	81	·48	9	8	10	·49	9	9	11	·50	10	9	12
48	37	83	·49	9	8	10	·50	10	9	11	·50	11	9	12
50	38	84					·50	10	9	11	·50	11	9	12

Rivets $\frac{7}{8}$ inch diameter.

SEE SECT 5. PAR 9 (b) RE SPACING OF GUSSETS, MIN^m Nº OF RIVS, ETC. GUSSETS TO BE BASED ON ACTUAL FRAME SIZE WITH NO CORRECTION FOR SPACING.

NOTES.—TABLE 11.

1. **Corrections.**—If the frame spacing amidships is greater / less than that given in the Table, the thickness of the tank side brackets is to be increased / reduced at the rate of ·01 inch for every two inches of difference.

2. The height of tank side brackets is to be measured at the inner edge of the frame.

TO MARGIN PLATE AND FRAMES.

TABLE 11
(CONCLUDED.)

f_y = FRAME. 61·55 TO 77·10. f_y = 80·05 TO 102·05

13½ INCH BULB ANGLE.				15 INCH CHANNEL. ·43 – ·69				17 INCH CHANNEL. ·48" – ·78"				DEPTH D
THICKNESS OF TANK SIDE BRACKET AND GUSSET.	NUMBER AND DIAMETER OF RIVETS PER FRAME SPACE			THICKNESS OF TANK SIDE BRACKET AND GUSSET.	NUMBER AND DIAMETER OF RIVETS PER FRAME SPACE.			THICKNESS OF TANK SIDE BRACKET AND GUSSET.	NUMBER AND DIAMETER OF RIVETS PER FRAME SPACE.			
	ANGLE TO MARGIN.	GUSSET.	⊬ FRAME CONNECTION.		ANGLE TO MARGIN.	GUSSET.	⊬ FRAME CONNECTION.		ANGLE TO MARGIN.	GUSSET.	⊬ FRAME CONNECTION.	
Inches.				Inches.				Inches				Feet.
												10
												12
												14
												16
												18
												20
												22
												24
·43	9	7	10		9	8	11					26
·44	9	8	10	·45	9	9	12	·46	10	9	14	28
·45	10	8	10	·46	10	9	12	·47	11	9	14	30
·46	10	8	11	·46	10	9	12	·47	11	9	14	32
·47	10	8	11	·47	10	9	12	·48	11	10	14	34
·48	10	8	11	·48	10	9	12	·49	11	10	14	36
·49	10	8	11	·49	11	9	12	·50	11	10	14	38
·50	10	9	11	·50	11	10	12	·51	12	11	15	40
·51	11	9	12	·51	11	10	13	·52	12	11	15	42
·51	11	9	12	·52	12	10	13	·52	12	11	15	44
·51	11	9	12	·52	12	10	13	·52	13	11	15	46
·52	12	10	12	·52	13	11	13	·52	14	12	15	48
·52	12	10	12	·52	13	11	13	·52	14	12	15	50

Rivets $\frac{7}{8}$ inch diameter.

⊬ (90) THE NUMBER OF RIVETS IN THE FRAME CONNECTION IS APPLICABLE WHEN OVERLAP OF FRAME ON TANK SIDE BRACKET IS 2½ TIMES THE DEPTH OF FRAME. WHERE TOP EDGE OF WING BRACKET IS HORIZONTAL, NUMBER OF RIVETS IN FRAME CONNECTION IS TO BE INCREASED BY 15%.

NOTES.—TABLE 11 (*continued*).

3. The angles connecting the tank side brackets to the margin plate are to have the same thickness as the brackets.

4. **In Boiler Rooms,** the tank side brackets, gussets and connecting angles are to be increased by ·10 inch in thickness.

5. For increases in way of panting region *see* **Section 9, clause 3** (*b*).

TABLE 12

(SEE CONTINUATION.)

MAIN FRAMING.

DEPTH D	FRAME SPACING AMIDSHIPS	BASIC DRAUGHT d_b	FRAMING IN PEAKS	CORRECTION TO MODULUS OF MAIN FRAMING PER 1 FT. DIFFERENCE BETWEEN d and d_b	DEPTH h FROM TOP OF DOUBLE BOTTOM OR SINGLE BOTTOM FLOOR AT SIDE TO TOP OF BEAM AT SIDE OF LOWEST DECK — FEET: 8	10	12	13	14	15	16	17	18
9	20 3/4	7·2			1·16								
Feet.	Inches.	Feet.	INCHES *Modulus—Inches³*	Per Cent.	INCHES *Modulus—Inches³*								
10	21	8·0	$3\frac{1}{2}\times2\frac{1}{2}\times\cdot35$ *1·50*	*15·0*	$3\frac{1}{2}\times3\times\cdot29$ *1·25*	$3\frac{1}{2}\times3\times\cdot35$ *1·50*	$3\frac{1}{2}\times3\times\cdot42$ *1·80*	$4\times3\times\cdot36$ *2·00*	$4\times3\times\cdot40$ *2·20*				
11	$21\frac{1}{4}$	8·8	$3\frac{1}{2}\times2\frac{1}{2}\times\cdot41$ *1·75*	*14·0*	$3\frac{1}{2}\times3\times\cdot32$ *1·40*	$3\frac{1}{2}\times3\times\cdot40$ *1·75*	$4\times3\times\cdot40$ *2·20*	$4\times3\times\cdot45$ *2·45*	$5\times3\times\cdot32$ *2·70*	$5\times3\times\cdot36$ *3·00*			
12	$21\frac{1}{2}$	9·6	$4\times3\times\cdot36$ *2·00*	*13·0*	$3\frac{1}{2}\times3\times\cdot37$ *1·60*	$4\times3\times\cdot37$ *2·05*	$5\times3\times\cdot31$ *2·60*	$5\times3\times\cdot35$ *2·95*	$5\times3\times\cdot39$ *3·25*	$5\times3\times\cdot44$ *3·65*	$6\times3\times\cdot33$ *4·00*		
13	$21\frac{3}{4}$	10·4	$4\times3\times\cdot39$ *2·70*	*12·0*		$4\times3\times\cdot44$ *2·40*	$5\times3\times\cdot36$ *3·00*	$5\times3\times\cdot41$ *3·40*	$5\times3\times\cdot46$ *3·80*	$6\times3\times\cdot35$ *4·20*	$6\times3\times\cdot39$ *4·65*	$6\times3\times\cdot44$ *5·20*	
14	22	11·2	$5\times3\times\cdot41$ *3·40*	*11·0*		$5\times3\times\cdot34$ *2·85*	$5\times3\times\cdot43$ *3·55*	$6\times3\times\cdot33$ *4·00*	$6\times3\times\cdot37$ *4·40*	$6\times3\times\cdot41$ *4·85*	$6\times3\times\cdot46$ *5·40*	$6\times3\times\cdot51$ *6·00*	$5\frac{1}{2}\times3\times\cdot42$ *6·50*
15	$22\frac{1}{4}$	12·0	$5\times3\times\cdot43$ *3·60*	*10·5*		$5\times3\times\cdot40$ *3·30*	$6\times3\times\cdot34$ *4·10*	$6\times3\times\cdot38$ *4·55*	$6\times3\times\cdot43$ *5·10*	$6\times3\times\cdot48$ *5·65*	$5\frac{1}{2}\times3\times\cdot39$ *6·15*	$6\times3\times\cdot34$ *6·80*	$6\times3\times\cdot38$ *7·35*
16	$22\frac{1}{2}$	12·8	$5\times3\times\cdot46$ *3·80*	*10·0*				$6\times3\times\cdot44$ *5·20*	$6\times3\times\cdot49$ *5·75*	$5\frac{1}{2}\times3\times\cdot40$ *6·25*	$6\times3\times\cdot35$ *6·95*	$6\times3\times\cdot39$ *7·50*	$6\times3\times\cdot44$ *8·20*
17	$22\frac{3}{4}$	13·6	$6\times3\times\cdot34$ *4·10*	*9·5*					$6\times3\times\cdot32$ *6·50*	$6\times3\times\cdot36$ *7·10*	$6\times3\times\cdot41$ *7·80*	$6\times3\times\cdot46$ *8·45*	$6\times3\times\cdot51$ *9·15*
18	23	14·4	$6\times3\times\cdot36$ *4·30*	*9·0*	$6\times3\times\cdot50$ *5·85*	$5\frac{1}{2}\times3\times\cdot38$ *6·05*	$5\frac{1}{2}\times3\times\cdot42$ *6·50*	$6\times3\times\cdot35$ *6·95*	$6\times3\times\cdot39$ *7·50*	$6\times3\times\cdot43$ *8·05*	$6\times3\times\cdot48$ *8·75*	$7\times3\times\cdot33$ *9·45*	$7\times3\times\cdot39$ *10·45*
19	$23\frac{1}{4}$	15·2	$6\times3\times\cdot40$ *4·75*	*8·5*	$5\frac{1}{2}\times3\times\cdot40$ *6·25*	$5\frac{1}{2}\times3\times\cdot43$ *6·60*	$6\times3\times\cdot38$ *7·35*	$6\times3\times\cdot41$ *7·80*	$6\times3\times\cdot46$ *8·45*	$6\times3\times\cdot51$ *9·15*	$7\times3\times\cdot36$ *9·95*	$7\times3\times\cdot41$ *10·80*	$7\times3\times\cdot47$ *11·85*
20	$23\frac{1}{2}$	16·0	$6\times3\times\cdot43$ *5·10*	*8·0*	$6\times3\times\cdot34$ *6·80*	$6\times3\times\cdot37$ *7·25*	$6\times3\times\cdot44$ *8·20*	$6\times3\times\cdot48$ *8·75*	*9·50*	$7\times3\times\cdot38$ *10·25*	$7\times3\times\cdot43$ *11·15*	$7\times3\times\cdot49$ *12·25*	*13·35*
21	$23\frac{3}{4}$	16·8	$5\frac{1}{2}\times3\times\cdot34$ *5·60*	*7·5*	$6\times3\times\cdot38$ *7·35*	$6\times3\times\cdot42$ *7·90*	$6\times3\times\cdot48$ *8·75*	*9·35*	$7\times3\times\cdot37$ *10·10*	$7\times3\times\cdot42$ *10·95*	$7\times3\times\cdot48$ *12·05*	*12·95*	$8\times3\times\cdot39$ *14·10*
22	24	17·6	$5\frac{1}{2}\times3\times\cdot39$ *6·15*	*7·0*	$6\times3\times\cdot42$ *7·90*	$6\times3\times\cdot46$ *8·45*	*9·50*	$7\times3\times\cdot37$ *10·10*	$7\times3\times\cdot42$ *10·95*	$7\times3\times\cdot47$ *11·85*	*13·00*	$8\times3\times\cdot38$ *13·85*	$8\times3\times\cdot45$ *15·45*
23	$24\frac{1}{2}$	18·4	$6\times3\times\cdot33$ *6·65*	*6·6*	$6\times3\times\cdot47$ *8·60*	*9·20*	$7\times3\times\cdot38$ *10·25*	$7\times3\times\cdot42$ *10·95*	$7\times3\times\cdot47$ *11·85*	*12·75*	$8\times3\times\cdot38$ *13·85*	$8\times3\times\cdot43$ *15·00*	$8\times3\times\cdot49$ *16·35*
24	25	19·2	$6\times3\times\cdot37$ *7·25*	*6·3*	*9·30*	$7\times3\times\cdot36$ *9·95*	$7\times3\times\cdot42$ *10·95*	$7\times3\times\cdot47$ *11·85*	*12·70*	$8\times3\times\cdot37$ *13·65*	$8\times3\times\cdot42$ *14·75*	$8\times3\times\cdot48$ *16·10*	*17·40*
25	$25\frac{1}{2}$	20·0	$6\times3\times\cdot42$ *7·90*	*6·0*	$7\times3\times\cdot37$ *10·10*	$7\times3\times\cdot41$ *10·80*	$7\times3\times\cdot47$ *11·85*	*12·65*	$8\times3\times\cdot37$ *13·65*	$8\times3\times\cdot41$ *14·55*	$8\times3\times\cdot47$ *15·90*	$8\times3\frac{1}{2}\times\cdot51$ *16·95*	*18·55*
26	26	20·8	$6\times3\times\cdot46$ *8·45*	*5·8*	$7\times3\times\cdot42$ *10·95*	$7\times3\times\cdot45$ *11·50*	$7\times3\times\cdot52$ *12·80*	*13·60*	$8\times3\times\cdot41$ *14·55*	$8\times3\times\cdot46$ *15·65*	$8\times3\times\cdot51$ *16·85*	*18·15*	$9\times3\frac{1}{2}\times\cdot43$ *19·65*
27	$26\frac{1}{2}$	21·6	$6\times3\times\cdot52$ *9·30*	*5·6*	$7\times3\times\cdot47$ *11·85*	$7\times3\times\cdot50$ *12·40*	*13·70*	$8\times3\times\cdot41$ *14·55*	$8\times3\times\cdot46$ *15·65*	$8\times3\times\cdot50$ *16·60*	*18·00*	$9\times3\frac{1}{2}\times\cdot42$ *19·40*	$9\times3\frac{1}{2}\times\cdot48$ *21·05*
28	27	22·4	$7\times3\times\cdot36$ *9·95*	*5·4*	$7\times3\times\cdot51$ *12·60*	*13·30*	$8\times3\times\cdot42$ *14·75*	$8\times3\times\cdot46$ *15·65*	$8\times3\frac{1}{2}\times\cdot49$ *16·45*	*17·75*	$9\times3\frac{1}{2}\times\cdot41$ *19·15*	$9\times3\frac{1}{2}\times\cdot47$ *20·80*	$9\times3\frac{1}{2}\times\cdot58$ *22·45*
29	$27\frac{1}{2}$	23·2	$7\times3\times\cdot41$ *10·80*	*5·2*	*13·75*	$8\times3\times\cdot40$ *14·30*	$8\times3\times\cdot46$ *15·65*	$8\times3\times\cdot50$ *16·60*	*17·75*	$9\times3\frac{1}{2}\times\cdot40$ *18·90*	$9\times3\frac{1}{2}\times\cdot46$ *20·50*	$9\times3\frac{1}{2}\times\cdot52$ *22·20*	*24·00*
30	28	24·0	$7\times3\times\cdot45$ *11·50*	*5·0*	$8\times3\times\cdot42$ *14·75*	$8\times3\times\cdot45$ *15·45*	$8\times3\frac{1}{2}\times\cdot50$ *16·70*	*17·75*	$9\times3\frac{1}{2}\times\cdot40$ *18·90*	$9\times3\frac{1}{2}\times\cdot45$ *20·20*	$9\times3\frac{1}{2}\times\cdot51$ *21·90*	$9\times3\frac{1}{2}\times\cdot57$ *23·60*	$10\times3\frac{1}{2}\times\cdot45$ *25·80*

ANGLES / BULB ANGLES

Section moduli above are given to nearest ·05.

For Notes see page 97.

31 28½ 24·8 12·60 4·8 16·0 16·7 17·8 18·9 20·2 21·6 23·3 25·15 27·10

MAIN FRAMING.

TABLE 12

(SEE CONTINUATION.)

DEPTH D	FRAME SPACING AMIDSHIPS	BASIC DRAUGHT d_b	CORRECTION TO MODULUS OF MAIN FRAMING PER 1 FT. DIFFERENCE BETWEEN d and d_b		DEPTH h FROM TOP OF DOUBLE BOTTOM OR SINGLE BOTTOM FLOOR AT SIDE TO TOP OF BEAM AT SIDE OF LOWEST DECK — FEET							
					19	20	21	22	23	24	25	26
Feet.	Inches.	Feet.	Per Cent.		INCHES — Modulus—Inches³							
10	21	8·0	*15·0*	ANGLES								
11	$21\frac{1}{4}$	8·8	*14·0*	ANGLES								
12	$21\frac{1}{2}$	9·6	*13·0*	ANGLES								
13	$22\frac{3}{4}$	10·4	*12·0*	ANGLES								
14	22	11·2	*11·0*	ANGLES								
15	$22\frac{1}{4}$	12·0	*10·5*	ANGLES	6 × 3 × ·43 *8·05*							
16	$22\frac{1}{2}$	12·8	*10·0*	ANGLES	6 × 3 × ·50 *9·00*	7 × 3 × ·35 *9·80*						
17	$22\frac{3}{4}$	13·6	*9·5*	ANGLES	7 × 3 × ·37 *10·10*	7 × 3 × ·43 *11·15*	7 × 3 × ·48 *12·05*					
18	23	14·4	*9·0*	ANGLES	7 × 3 × ·45 *11·50*	7 × 3 × ·50 *12·40*	8 × 3 × ·37 *13·65*	8 × 3 × ·42 *14·75*				
19	$23\frac{1}{4}$	15·2	*8·5*	ANGLES	7 × 3 × ·52 *12·80*	8 × 3 × ·39 *14·10*	8 × 3 × ·44 *15·20*	8 × 3 × ·50 *16·60*	8 × 3 × ·55 *17·80*			
20	$23\frac{1}{2}$	16·0	*8·0*	ANGLES	8 × 3 × ·41 *14·55*	8 × 3 × ·46 *15·65*	8 × 3 × ·52 *17·10*	*18·50*	9 × 3½ × ·44 *19·90*	9 × 3½ × ·50 *21·60*		
21	$23\frac{3}{4}$	16·8	*7·5*	ANGLES	8 × 3 × ·46 *15·65*	8 × 3 × ·51 *16·85*	*18·30*	9 × 3½ × ·44 *19·90*	9 × 3½ × ·50 *21·60*	9 × 3½ × ·55 *23·00*	*24·70*	
22	24	17·6	*7·0*	BULB ANGLES	8 × 3 × ·50 *16·60*	*18·00*	9 × 3½ × ·43 *19·65*	9 × 3½ × ·48 *21·05*	9 × 3½ × ·55 *23·00*	*24·85*	10 × 3½ × ·47 *26·45*	10 × 3½ × ·52 *28·10*
23	$24\frac{1}{2}$	18·4	*6·6*	BULB ANGLES	*17·75*	9 × 3½ × ·41 *19·15*	9 × 3½ × ·48 *21·05*	9 × 3½ × ·54 *22·70*	*24·55*	10 × 3½ × ·47 *26·45*	10 × 3½ × ·53 *28·45*	10 × 3½ × ·59 *30·45*
24	25	19·2	*6·3*	BULB ANGLES	9 × 3½ × ·39 *18·65*	9 × 3½ × ·46 *20·50*	9 × 3½ × ·52 *22·20*	*24·10*	10 × 3½ × ·46 *26·10*	10 × 3½ × ·52 *28·10*	10 × 3½ × ·59 *30·45*	*32·55*
25	$25\frac{1}{2}$	20·0	*6·0*	BULB ANGLES	9 × 3½ × ·45 *20·20*	9 × 3½ × ·51 *21·90*	9 × 3½ × ·58 *23·85*	*25·60*	10 × 3½ × ·51 *27·75*	10 × 3½ × ·58 *30·10*	*32·25*	11 × 3½ × ·52 *34·55*
26	26	20·8	*5·8*	BULB ANGLES	9 × 3½ × ·50 *21·60*	9 × 3½ × ·56 *23·30*	*25·25*	10 × 3½ × ·49 *27·10*	10 × 3½ × ·56 *29·45*	*31·90*	11 × 3½ × ·51 *34·20*	11 × 3½ × ·57 *36·60*
27	$26\frac{1}{2}$	21·6	*5·6*	BULB ANGLES	9 × 3½ × ·55 *23·00*	*24·75*	10 × 3½ × ·48 *26·80*	10 × 3½ × ·54 *28·80*	*31·40*	11 × 3½ × ·50 *33·80*	11 × 3½ × ·56 *36·20*	11 × 3½ × ·63 *39·00*
28	27	22·4	*5·4*	BULB ANGLES	*24·50*	10 × 3½ × ·47 *26·45*	10 × 3½ × ·54 *28·80*	*30·80*	11 × 3½ × ·49 *33·45*	11 × 3½ × ·55 *35·80*	11 × 3½ × ·62 *38·60*	12 × 3½ × ·50 *41·20*
29	$27\frac{1}{2}$	23·2	*5·2*	BULB ANGLES	10 × 3½ × ·46 *26·10*	10 × 3½ × ·52 *28·10*	10 × 3½ × ·59 *80·45*	11 × 3½ × ·47 *32·70*	11 × 3½ × ·54 *35·40*	11 × 3½ × ·61 *38·20*	12 × 3½ × ·49 *40·75*	12 × 3½ × ·55 *43·55*
30	28	24·0	*5·0*	BULB ANGLES	10 × 3½ × ·51 *27·75*	10 × 3½ × ·58 *30·10*	11 × 3½ × ·46 *32·30*	11 × 3½ × ·53 *35·00*	11 × 3½ × ·60 *37·80*	*40·40*	12 × 3½ × ·54 *43·05*	12 × 3½ × ·61 *46·40*

Section moduli above are given to nearest ·05.

For Notes see page 97.

31 29·45 31·75 34·2 37·0 39·8 42·6 45·9 48·6

TABLE 12

(SEE CONTINUATION.)

MAIN FRAMING.

DEPTH D	FRAME SPACING AMIDSHIPS	BASIC DRAUGHT d_b	*CORRECTION TO MODULUS OF MAIN FRAMING PER 1 FT. DIFFERENCE BETWEEN d and d_b*	DEPTH h FROM TOP OF DOUBLE BOTTOM OR SINGLE BOTTOM FLOOR AT SIDE TO TOP OF BEAM AT SIDE OF LOWEST DECK — FEET							
				27	28	29	30	31	32	33	34
Feet.	Inches.	Feet.	Per Cent.	INCHES *Modulus—Inches³*							
10	21	8·0	*15·0*								
11	$21\frac{1}{4}$	8·8	*14·0*								
12	$21\frac{1}{2}$	9·6	*13·0*								
13	$21\frac{3}{4}$	10·4	*12·0*								
14	22	11·2	*11·0*								
15	$22\frac{1}{4}$	12·0	*10·5*								
16	$22\frac{1}{2}$	12·8	*10·0*								
17	$22\frac{3}{4}$	13·6	*9·5*								
18	23	14·4	*9·0*								
19	$23\frac{1}{4}$	15·2	*8·5*								
20	$23\frac{1}{2}$	16·0	*8·0*								
21	$23\frac{3}{4}$	16·8	*7·5*								
22	24	17·6	*7·0*								
23	$24\frac{1}{2}$	18·4	*6·6*	*32·65*							
24	25	19·2	*6·3*	11×3½×·52 *34·55*	11×3½×·58 *37·00*						
25	$25\frac{1}{2}$	20·0	*6·0*	11×3½×·58 *37·00*	11×3½×·64 *39·40*	12×3½×·51 *41·65*	12×3½×·56 *44·00*				
26	26	20·8	*5·8*	11×3½×·64 *39·40*	12×3½×·51 *41·65*	12×3½×·56 *44·00*	12×3½×·62 *46·85*	12×4×4×·56 *49·40*			
27	$26\frac{1}{2}$	21·6	*5·6*	12×3½×·51 *41·65*	12×3½×·56 *44·00*	12×3½×·62 *46·85*	12×4×4×·57 *49·80*	12×4×4×·63 *52·20*	*55·00*		
28	27	22·4	*5·4*	12×3½×·56 *44·00*	12×3½×·62 *46·85*	12×4×4×·57 *49·80*	12×4×4×·64 *52·60*	*55·30*	*58·15*	15×4×4×·42 *60·95*	
29	$27\frac{1}{2}$	23·2	*5·2*	12×3½×·62 *46·85*	12×4×4×·57 *49·80*	12×4×4×·64 *52·60*	*55·55*	*58·55*	15×4×4×·43 *61·55*	15×4×4×·48 *64·60*	15×4×4×·53 *67·65*
30	28	24·0	*5·0*	12×4×4×·56 *49·40*	12×4×4×·64 *52·60*	*55·50*	*58·75*	15×4×4×·44 *62·15*	15×4×4×·49 *65·25*	15×4×4×·54 *68·25*	15×4×4×·60 *71·80*

ANGLES — BULB ANGLES — CH.

Section moduli above are given to nearest ·05.

For Notes see page 97.

MAIN FRAMING.

TABLE 12

(SEE CONTINUATION.)

DEPTH D	FRAME SPACING AMID-SHIPS	BASIC DRAUGHT d_b	FRAMING IN PEAKS	CORRECTION TO MODULUS OF MAIN FRAMING PER 1 FT. DIFFERENCE BETWEEN d and d_b	DEPTH h FROM TOP OF DOUBLE BOTTOM OR SINGLE BOTTOM FLOOR AT SIDE TO TOP OF BEAM AT SIDE OF LOWEST DECK — FEET								
					8	10	12	13	14	15	16	17	18
Feet.	Inches.	Feet.	INCHES *Modulus—Inches³*	Per Cent.	<— INCHES *Modulus—Inches³* —>								
31	28½	24·8	7 × 3 × ·51 *12·60*	*4·8*	8 × 3½ × ·47 *16·00*	8 × 3½ × ·50 *16·70*	 *17·80*	9 × 3½ × ·40 *18·90*	9 × 3½ × ·45 *22·20*	9 × 3½ × ·50 *21·60*	9 × 3½ × ·56 *23·30*	10 × 3½ × ·43 *25·15*	10 × 3½ × ·49 *27·10*
32	29	25·6	8 × 3 × ·38 *13·85*	*4·6*	8 × 3½ × ·51 *16·95*	 *17·70*	9 × 3½ × ·41 *19·15*	9 × 3½ × ·45 *20·20*	9 × 3½ × ·49 *21·35*	9 × 3½ × ·55 *23·00*	10 × 3½ × ·42 *24·80*	10 × 3½ × ·47 *26·45*	10 × 3½ × ·54 *28·80*
33	29½	26·4	8 × 3 × ·44 *15·20*	*4·4*	 *18·25*	9 × 3½ × ·40 *18·90*	9 × 3½ × ·46 *20·50*	9 × 3½ × ·49 *21·35*	9 × 3½ × ·54 *22·70*	9 × 3½ × ·59 *24·15*	10 × 3½ × ·45 *25·80*	10 × 3½ × ·52 *28·10*	10 × 3½ × ·59 *30·45*
34	30	27·2	8 × 3 × ·50 *16·60*	*4·3*	9 × 3½ × ·43 *19·65*	9 × 3½ × ·45 *20·20*	9 × 3½ × ·50 *21·60*	9 × 3½ × ·54 *22·70*	9 × 3½ × ·58 *23·85*	10 × 3½ × ·44 *25·45*	10 × 3½ × ·50 *27·40*	10 × 3½ × ·56 *29·45*	11 × 3½ × ·45 *31·95*
35	30½	28·0	8 × 3 × ·55 *17·80*	*4·2*	9 × 3½ × ·46 *20·50*	9 × 3½ × ·50 *21·60*	9 × 3½ × ·55 *23·00*	9 × 3½ × ·59 *24·15*	10 × 3½ × ·44 *25·45*	10 × 3½ × ·48 *26·80*	10 × 3½ × ·54 *28·80*	10 × 3½ × ·60 *30·80*	11 × 3½ × ·49 *33·45*
36	31	28·8	9 × 3½ × ·41 *19·15*	*4·1*	9 × 3½ × ·51 *21·90*	9 × 3½ × ·54 *22·70*	9 × 3½ × ·59 *24·15*	10 × 3½ × ·44 *25·45*	10 × 3½ × ·48 *26·80*	10 × 3½ × ·52 *28·10*	10 × 3½ × ·58 *30·10*	11 × 3½ × ·46 *32·30*	11 × 3½ × ·53 *35·00*
37	31½	29·4	9 × 3½ × ·45 *20·20*	*4·0*	9 × 3½ × ·56 *23·30*	9 × 3½ × ·58 *23·85*	10 × 3½ × ·44 *25·45*	10 × 3½ × ·48 *26·80*	10 × 3½ × ·52 *28·10*	10 × 3½ × ·57 *29·75*	11 × 3½ × ·44 *31·55*	11 × 3½ × ·50 *33·80*	11 × 3½ × ·57 *36·60*
38	32	30·0	 *21·20*	*4·0*	9 × 3½ × ·59 *24·15*	10 × 3½ × ·43 *25·15*	10 × 3½ × ·47 *26·45*	10 × 3½ × ·51 *27·75*	10 × 3½ × ·55 *29·15*	10 × 3½ × ·60 *30·80*	11 × 3½ × ·47 *32·70*	11 × 3½ × ·54 *35·40*	11 × 3½ × ·60 *37·80*
39	32½	30·0	 *21·40*	*4·0*	10 × 3½ × ·42 *24·80*	10 × 3½ × ·44 *25·45*	10 × 3½ × ·50 *27·40*	10 × 3½ × ·53 *28·45*	10 × 3½ × ·58 *30·10*	10 × 3½ × ·62 *31·45*	11 × 3½ × ·50 *33·80*	11 × 3½ × ·56 *36·20*	11 × 3½ × ·63 *39·00*
40	33	30·0	9 × 3½ × ·50 *21·60*	*4·0*	10 × 3½ × ·44 *25·45*	10 × 3½ × ·47 *26·45*	10 × 3½ × ·53 *28·45*	10 × 3½ × ·56 *29·45*	10 × 3½ × ·60 *30·80*	11 × 3½ × ·47 *32·70*	11 × 3½ × ·53 *35·00*	11 × 3½ × ·59 *37·40*	12 × 3½ × ·47 *39·90*
41	33½	30·0	 *21·80*	*4·0*	10 × 3½ × ·46 *26·10*	10 × 3½ × ·50 *27·40*	10 × 3½ × ·55 *29·15*	10 × 3½ × ·59 *30·45*	11 × 3½ × ·45 *31·95*	11 × 3½ × ·49 *33·45*	11 × 3½ × ·55 *35·80*	11 × 3½ × ·61 *38·20*	12 × 3½ × ·50 *41·20*
42	34	30·0	 *22·00*	*4·0*	10 × 3½ × ·49 *27·10*	10 × 3½ × ·52 *28·10*	10 × 3½ × ·58 *30·10*	10 × 3½ × ·61 *31·15*	11 × 3½ × ·47 *32·70*	11 × 3½ × ·52 *34·55*	11 × 3½ × ·57 *36·60*	11 × 3½ × ·62 *38·60*	12 × 3½ × ·52 *42·10*
43	34½	30·0	9 × 3½ × ·52 *22·20*	*4·0*	10 × 3½ × ·51 *27·75*	10 × 3½ × ·55 *29·15*	10 × 3½ × ·60 *30·80*	11 × 3½ × ·46 *32·30*	11 × 3½ × ·50 *33·80*	11 × 3½ × ·54 *35·40*	11 × 3½ × ·60 *37·80*	12 × 3½ × ·48 *40·30*	12 × 3½ × ·55 *43·55*
44	35	30·0	 *22·40*	*4·0*	10 × 3½ × ·53 *28·45*	10 × 3½ × ·57 *29·80*	11 × 3½ × ·45 *31·95*	11 × 3½ × ·48 *33·05*	11 × 3½ × ·52 *34·55*	11 × 3½ × ·57 *36·60*	11 × 3½ × ·62 *38·60*	12 × 3½ × ·50 *41·20*	12 × 3½ × ·57 *44·50*
45	35½	30·0	 *22·60*	*4·0*	10 × 3½ × ·56 *29·45*	10 × 3½ × ·59 *30·45*	11 × 3½ × ·47 *32·50*	11 × 3½ × ·51 *34·20*	11 × 3½ × ·55 *35·80*	11 × 3½ × ·59 *37·40*	12 × 3½ × ·46 *39·45*	12 × 3½ × ·52 *42·10*	12 × 3½ × ·59 *45·45*
46	36	30·0	 *22·80*	*4·0*	10 × 3½ × ·58 *30·10*	10 × 3½ × ·61 *31·15*	11 × 3½ × ·50 *33·80*	11 × 3½ × ·53 *35·00*	11 × 3½ × ·57 *36·60*	11 × 3½ × ·61 *38·20*	12 × 3½ × ·49 *40·75*	12 × 3½ × ·55 *43·55*	12 × 3½ × ·61 *46·40*
47	36½	30·0	9 × 3½ × ·55 *23·00*	*4·0*	10 × 3½ × ·60 *30·80*	11 × 3½ × ·46 *32·30*	11 × 3½ × ·52 *34·55*	11 × 3½ × ·55 *35·80*	11 × 3½ × ·59 *37·40*	11 × 3½ × ·69 *39·40*	12 × 3½ × ·51 *41·65*	12 × 3½ × ·57 *44·50*	12 × 3½ × ·64 *47·75*
48	37	30·0	 *23·20*	*4·0*	11 × 3½ × ·44 *31·55*	11 × 3½ × ·48 *33·05*	11 × 3½ × ·54 *35·40*	11 × 3½ × ·57 *36·60*	11 × 3½ × ·62 *38·60*	12 × 3½ × ·48 *40·30*	12 × 3½ × ·53 *42·60*	12 × 3½ × ·59 *45·45*	12 × 4 × 4 × ·54 *48·60*
49	37½	30·0	 *23·40*	*4·0*	11 × 3½ × ·46 *32·30*	11 × 3½ × ·50 *33·80*	11 × 3½ × ·56 *36·20*	11 × 3½ × ·60 *37·80*	11 × 3½ × ·64 *39·40*	12 × 3½ × ·50 *41·20*	12 × 3½ × ·55 *43·55*	12 × 3½ × ·61 *46·40*	12 × 4 × 4 × ·57 *49·80*
50	38	30·0	9 × 3½ × ·57 *23·60*	*4·0*	11 × 3½ × ·48 *33·05*	11 × 3½ × ·52 *34·55*	11 × 3½ × ·59 *37·40*	11 × 3½ × ·62 *38·60*	12 × 3½ × ·48 *40·30*	12 × 3½ × ·52 *42·10*	12 × 3½ × ·58 *44·95*	12 × 3½ × ·64 *47·75*	12 × 4 × 4 × ·60 *51·00*

↑ BULB ANGLES ↓

Section moduli above are given to nearest ·05.

For Notes see page 97.

TABLE 12

(SEE CONTINUATION.)

MAIN FRAMING.

DEPTH D	FRAME SPACING AMIDSHIPS	BASIC DRAUGHT d_b	CORRECTION TO MODULUS OF MAIN FRAMING PER 1 FT. DIFFERENCE BETWEEN d and d_b	DEPTH h FROM TOP OF DOUBLE BOTTOM OR SINGLE BOTTOM FLOOR AT SIDE TO TOP OF BEAM AT SIDE OF LOWEST DECK — FEET							
				19	20	21	22	23	24	25	26
Feet.	Inches.	Feet.	Per Cent.	INCHES — *Modulus—Inches³*							
31	28½	24·8	4·8	10×3½×·56 *29·45*		11×3½×·51 *34·20*	11×3½×·58 *37·00*	11×3½×·65 *39·80*	12×3½×·53 *42·60*	12×3½×·60 *45·90*	12×4×4×·54 *48·60*
32	29	25·6	4·6	10×3½×·61 *31·15*	11×3½×·49 *33·45*	11×3½×·56 *36·20*	11×3½×·64 *39·40*	12×3½×·52 *42·10*	12×3½×·59 *45·45*	12×4×4×·53 *48·20*	12×4×4×·61 *51·40*
33	29½	26·4	4·4	11×3½×·47 *32·70*	11×3½×·54 *35·40*	11×3½×·61 *38·20*	12×3½×·50 *41·20*	12×3½×·55 *43·55*	12×3½×·64 *47·75*	12×4×4×·60 *51·00*	12×4×4×·68 *54·15*
34	30	27·2	4·3	11×3½×·52 *34·55*	11×3½×·58 *37·00*	12×3½×·48 *40·30*	12×3½×·55 *43·55*	12×3½×·62 *46·85*	12×4×4×·58 *50·20*	12×4×4×·66 *53·35*	*57·00*
35	30½	28·0	4·2	11×3½×·56 *36·20*	11×3½×·63 *39·00*	12×3½×·52 *42·10*	12×3½×·59 *45·45*	12×4×4×·55 *49·00*	12×4×4×·64 *52·60*	*56·05*	*60·00*
36	31	28·8	4·1	11×3½×·59 *37·40*	12×3½×·49 *40·75*	12×3½×·56 *44·00*	12×4×4×·51 *47·40*	12×4×4×·60 *51·00*	*54·95*	*58·80*	15×4×4×·45 *62·75*
37	31½	29·4	4·0	11×3½×·65 *39·80*	12×3½×·53 *42·60*	12×3½×·61 *46·40*	12×4×4×·57 *49·80*	12×4×4×·67 *53·75*	*57·40*	15×4×4×·43 *61·55*	15×4×4×·49 *65·25*
38	32	30·0	4·0	12×3½×·49 *40·75*	12×3½×·56 *44·00*	12×3½×·64 *47·75*	12×4×4×·61 *51·40*	*55·25*	*59·30*	15×4×4×·46 *63·35*	15×4×4×·54 *68·25*
39	32½	30·0	4·0	12×3½×·52 *42·10*	12×3½×·59 *45·45*	12×4×4×·55 *49·00*	12×4×4×·64 *52·60*	*56·50*	*60·50*	15×4×4×·49 *65·25*	15×4×4×·56 *69·45*
40	33	30·0	4·0	12×3½×·54 *43·05*	12×3½×·61 *46·40*	12×4×4×·58 *50·20*	12×4×4×·68 *54·15*	*57·80*	15×4×4×·44 *62·15*	15×4×4×·50 *65·85*	15×4×4×·57 *70·05*
41	33½	30·0	4·0	12×3½×·57 *44·50*	12×3½×·64 *47·75*	12×4×4×·61 *51·40*	*55·10*	*59·10*	15×4×4×·45 *62·75*	15×4×4×·52 *67·05*	15×4×4×·60 *71·80*
42	34	30·0	4·0	12×3½×·59 *45·45*	12×4×4×·55 *49·00*	12×4×4×·65 *53·00*	*56·40*	*60·30*	15×4×4×·48 *64·60*	15×4×4×·55 *68·85*	15×4×4×·62 *73·00*
43	34½	30·0	4·0	12×3½×·62 *46·85*	12×4×4×·58 *50·20*	12×4×4×·67 *53·75*	*57·70*	15×4×4×·43 *61·55*	15×4×4×·49 *65·25*	15×4×4×·56 *69·45*	15×4×4×·64 *74·20*
44	35	30·0	4·0	12×3½×·64 *47·75*	12×4×4×·61 *51·40*	*55·10*	*59·00*	15×4×4×·45 *62·75*	15×4×4×·52 *67·05*	15×4×4×·59 *71·25*	15×4×4×·66 *75·35*
45	35½	30·0	4·0	12×4×4×·55 *49·00*	12×4×4×·64 *52·60*	*56·30*	*60·25*	15×4×4×·47 *64·00*	15×4×4×·54 *68·25*	15×4×4×·61 *72·40*	*76·90*
46	36	30·0	4·0	12×4×4×·58 *50·20*	12×4×4×·67 *53·75*	*57·60*	15×4×4×·43 *61·55*	15×4×4×·50 *65·85*	15×4×4×·56 *69·45*	15×4×4×·63 *73·60*	*78·20*
47	36½	30·0	4·0	12×4×4×·61 *51·40*	*54·90*	*58·80*	15×4×4×·45 *62·75*	15×4×4×·51 *66·45*	15×4×4×·58 *70·65*	15×4×4×·65 *74·80*	*79·45*
48	37	30·0	4·0	12×4×4×·64 *52·60*	*56·10*	*60·05*	15×4×4×·47 *64·00*	15×4×4×·53 *67·65*	15×4×4×·60 *71·80*	*76·05*	17×4×4×·49 *80·85*
49	37½	30·0	4·0	12×4×4×·67 *53·75*	*57·30*	15×4×4×·43 *61·55*	15×4×4×·49 *65·25*	15×4×4×·56 *69·45*	15×4×4×·62 *73·00*	*77·35*	17×4×4×·50 *81·60*
50	38	30·0	4·0	*54·70*	*58·50*	15×4×4×·45 *62·75*	15×4×4×·51 *66·45*	15×4×4×·58 *70·65*	15×4×4×·64 *74·20*	*78·60*	17×4×4×·52 *83·10*

BULB ANGLES — CHANNELS

Section moduli above are given to nearest ·05.

For Notes see page 97.

MAIN FRAMING.

TABLE 12 (CONCLUDED.)

DEPTH D	FRAME SPACING AMIDSHIPS	BASIC DRAUGHT d_b	CORRECTION TO MODULUS OF MAIN FRAMING PER 1 FT. DIFFERENCE BETWEEN d and d_b		DEPTH h FROM TOP OF DOUBLE BOTTOM OR SINGLE BOTTOM FLOOR AT SIDE TO TOP OF BEAM AT SIDE OF LOWEST DECK — FEET							
					27	28	29	30	31	32	33	34
Feet.	Inches.	Feet.	Per Cent.		INCHES — Modulus—Inches³							
31	28½	24·8	4·8	^	12×4×4×·62 *51·80*		*55·30*	*58·55*	15×4×4×·44 *62·15*	15×4×4×·49 *65·25*	15×4×4×·55 *68·85*	15×4×4×·60 *71·80*	15×4×4×·66 *75·35*
32	29	25·6	4·6	|	*54·95*	*58·45*	15×4×4×·44 *62·15*	15×4×4×·49 *65·25*	15×4×4×·55 *68·85*	15×4×4×·61 *72·40*	15×4×4×·68 *76·50*	*79·60*
33	29½	26·4	4·4	|	*57·95*	15×4×4×·43 *61·55*	15×4×4×·49 *65·25*	15×4×4×·55 *68·85*	15×4×4×·61 *72·40*	15×4×4×·68 *76·50*	17×4×4×·48 *80·05*	17×4×4×·52 *83·10*
34	30	27·2	4·3	|	*60·90*	15×4×4×·49 *65·25*	15×4×4×·54 *68·25*	15×4×4×·61 *72·40*	15×4×4×·68 *76·50*	*80·45*	17×4×4×·53 *83·85*	17×4×4×·59 *88·30*
35	30½	28·0	4·2	|	15×4×4×·47 *64·00*	15×4×4×·54 *68·25*	15×4×4×·61 *72·40*	15×4×4×·68 *76·50*	*80·40*	17×4×4×·53 *83·85*	17×4×4×·59 *88·30*	17×4×4×·65 *92·75*
36	31	28·8	4·1	|	15×4×4×·52 *67·05*	15×4×4×·59 *71·25*	15×4×4×·66 *75·35*	*80·00*	17×4×4×·53 *83·85*	17×4×4×·58 *87·55*	17×4×4×·65 *92·75*	17×4×4×·72 *97·80*
37	31½	29·4	4·0	|	15×4×4×·57 *70·05*	15×4×4×·65 *74·80*	*79·00*	17×4×4×·53 *83·85*	17×4×4×·59 *88·30*	17×4×4×·65 *92·75*	17×4×4×·71 *97·10*	17×4×4×·78 *102·05*
38	32	30·0	4·0	|	15×4×3×·61 *72·40*	15×4×4×·68 *76·50*	17×4×4×·50 *81·60*	17×4×4×·56 *86·10*	17×4×4×·62 *90·50*	17×4×4×·69 *95·65*	17×4×4×·77 *101·35*	
39	32½	30·0	4·0	|	15×4×4×·63 *73·60*	*78·25*	17×4×4×·52 *83·10*	17×4×4×·58 *87·55*	17×4×4×·64 *92·00*	17×4×4×·71 *97·10*		
40	33	30·0	4·0	CHANNELS	15×4×4×·65 *74·80*	*79·25*	17×4×4×·53 *83·85*	17×4×4×·59 *88·30*	17×4×4×·66 *93·45*	17×4×4×·72 *97·80*		
41	33½	30·0	4·0		15×4×4×·67 *75·95*	*80·50*	17×4×4×·55 *85·35*	17×4×4×·61 *89·75*	17×4×4×·67 *94·20*	17×4×4×·74 *99·25*		
42	34	30·0	4·0		15×4×4×·69 *77·10*	17×4×4×·50 *81·60*	17×4×4×·56 *86·10*	17×4×4×·63 *91·25*	17×4×4×·69 *95·65*	17×4×4×·76 *100·65*		
43	34½	30·0	4·0	|	*78·25*	17×4×4×·52 *83·10*	17×4×4×·58 *87·55*	17×4×4×·64 *92·00*	17×4×4×·71 *97·10*	17×4×4×·78 *102·05*		
44	35	30·0	4·0	|	*79·60*	17×4×4×·53 *83·85*	17×4×4×·60 *89·00*	17×4×4×·66 *93·45*	17×4×4×·73 *98·55*			
45	35½	30·0	4·0	|	17×4×4×·49 *80·85*	17×4×4×·55 *85·35*	17×4×4×·62 *90·50*	17×4×4×·68 *94·90*	17×4×4×·74 *99·25*			
46	36	30·0	4·0	|	17×4×4×·51 *82·35*	17×4×4×·57 *86·85*	17×4×4×·63 *91·25*	17×4×4×·70 *96·35*	17×4×4×·76 *100·65*			
47	36½	30·0	4·0	|	17×4×4×·53 *83·85*	17×4×4×·59 *88·30*	17×4×4×·65 *92·75*	17×4×4×·71 *97·10*				
48	37	30·0	4·0	|	17×4×4×·54 *84·60*	17×4×4×·60 *89·00*	17×4×4×·67 *94·20*	17×4×4×·73 *98·55*				
49	37½	30·0	4·0	|	17×4×4×·56 *86·10*	17×4×4×·62 *60·50*	17×4×4×·68 *94·90*					
50	38	30·0	4·0	v	17×4×4×·58 *87·55*	17×4×4×·64 *92·00*	17×4×4×·70 *96·35*					

Section moduli above are given to nearest ·05.

NOTES.—TABLE 12. SEE NOTE 64 (SECTION 34) RE SIDE FRAMES IN TUGS & TRAWLERS.

1. **Correction to Modulus of Peak Framing.**

FOR DRAUGHT.

If d is $\frac{\text{greater}}{\text{less}}$ than d_b, modulus to be $\frac{\text{increased}}{\text{reduced}}$ by 9 per cent per foot of difference.

(46) REDUCTION NOT TO EXCEED 40%.

2. **Corrections to Modulus of Main Framing.**—The Table modulus is to be corrected, if necessary, as follows:—

FOR DRAUGHT.

If d is $\frac{\text{greater}}{\text{less}}$ than d_b, modulus to be $\frac{\text{increased}}{\text{reduced}}$ by the percentage given in the Table per foot of difference.

FOR TANK SIDE BRACKETS AND BEAM KNEES. actual

If the height of the tank side brackets above the inner bottom is greater than that derived from **Tables 6** and **11** or the depth of the beam knees greater than that required by **Table 28** the modulus may be reduced at the rate of 4 per cent per foot of difference.

If the height of the tank side brackets above the inner bottom is less than that derived from **Tables 6** and **11** the modulus is to be increased at the rate of 8 per cent per foot of difference.

FOR FRAME SPACING.

If the spacing amidships differs from that given in the Table, modulus to be modified in direct proportion. (*See* also **Section 6, clause 2.**)

3. For increase in boiler rooms and coal bunkers *see* **Section 6, clause 6** (*b*).

4. Particulars of sections and moduli are given in **Table 56.**

(55) IF BEAM KNEES AT LOWEST DECK LESS THAN RULE, INCREASE FRAME MODULUS BY 4% PER FOOT. IF BOTH BEAM KNEES & T.S.B. DIFFER FROM RULE, FACTORS TO BE COMPOUNDED. IF DEEP KNEE FITTED FOR SCARPHED TW. DK. FRAME, CORRECTION TO BE APPLIED FOR DIFFERENCE BETWEEN THIS KNEE & NORMAL.

* (16) Col. F not corrected for draught or spacing nor 'tween deck height unless this is excessive.

(23) Col. F. is minimum for all frames. (except as qualified by (17).

TABLE 13

'TWEEN DECK FRAMING.

DEPTH D	FRAME SPACING AMIDSHIPS	BASIC DRAUGHT d_b	CORRECTION TO MODULUS PER 1 FT. DIFFERENCE BETWEEN d and d_b		A	B	C	D	E	* F	
Feet.	Inches.	Feet.	Per Cent.		INCHES — Modulus—Inches³						
12	21½	9·6	14·0	ANGLES		3 × 2½ × ·28 ·90	3 × 2½ × ·39 1·30			3 × 2½ × ·28 ·90	ANGLES
14	22	11·2	13·5			3 × 3 × ·34 1·15	3½ × 3 × ·37 1·60			3 × 3 × ·30 1·00	
16	22½	12·8	13·0			3½ × 3 × ·32 1·40	4 × 3 × ·36 2·00			3 × 3 × ·34 1·15	
18	23	14·4	12·5			3½ × 3 × ·38 1·65	4 × 3 × ·45 2·45	5 × 3 × ·40 3·30		3 × 3 × ·40 1·35	
20	23½	16·0	12·0			3½ × 3 × ·46 2·00	5 × 3 × ·36 3.00	5 × 3 × ·49 4·05		3½ × 3 × ·36 1·55	
22	24	17·6	11·4			4 × 3 × ·43 2·35	5 × 3 × ·45 3·70	6 × 3 × ·40 4·75		4 × 3 × ·32 1·80	
24	25	19·2	10·8		4 × 3 × ·41 2·25	5 × 3 × ·33 2·80	6 × 3 × ·38 4·55	5½ × 3 × ·34 5·60		4 × 3 × ·37 2·05	
26	26	20·8	10·2		4 × 3½ × ·50 2·75	5 × 3½ × ·39 3·25	6 × 3½ × ·47 5·50	6 × 3½ × ·31 6.50	6 × 3½ × ·48 8·80	4 × 3½ × ·44 2·40	
28	27	22·4	9·6		5 × 3½ × ·40 3·35	5 × 3½ × ·45 3·75	6 × 3½ × ·33 6·70	6 × 3½ × ·40 7·65	7 × 3½ × ·39 10·45	5 × 3½ × ·34 2·85	
30	28	24·0	9·0		5 × 3½ × ·48 4·00	6 × 3½ × ·38 4·50	6 × 3½ × ·43 8·05	6 × 3½ × ·50 9·05	7 × 3½ × ·48 12·05	5 × 3½ × ·41 3·40	
32	29	25·6	8·2		6 × 3½ × ·40 4·70	6 × 3½ × ·47 5·50	9·40	7 × 3½ × ·43 11·10	8 × 3½ × ·38 13·90	5 × 3½ × ·48 4·00	
34	30	27·2	7·4		6 × 3½ × ·47 5·50	6 × 3½ × ·31 6·50	7 × 3½ × ·43 11·10	13·00	8 × 3½ × ·47 15·95	6 × 3½ × ·40 4·70	
36	31	28·8	6·6	BULB ANGLES	6 × 3½ × ·31 6·50	6 × 3½ × ·40 7·65	7 × 3½ × ·53 13·00	8 × 3½ × ·45 15·50	9 × 3½ × ·38 18·40	6 × 3½ × ·46 5·40	BULB ANGLES
38	32	30·0	6·0		6 × 3½ × ·39 7·55	6 × 3½ × ·48 8·80	8 × 3½ × ·43 15·00	8 × 3½ × ·54 17·60	9 × 3½ × ·46 20·50	6 × 3½ × ·53 6·15	
40	33	30·0	6·0		6 × 3½ × ·42 7·95	9·35	8 × 3½ × ·47 15·95	9 × 3½ × ·39 18·65	9 × 3½ × ·51 21·90	6 × 3½ × ·32 6·60	
42	34	30·0	6·0		6 × 3½ × ·45 8·35	7 × 3½ × ·35 9·80	8 × 3½ × ·50 16·70	9 × 3½ × ·43 19·65	23·65	6 × 3½ × ·36 7·10	
44	35	30·0	6·0		6 × 3½ × ·49 8·90	7 × 3½ × ·39 10·45	17·75	9 × 3½ × ·48 21·05	10 × 3½ × ·43 25·10	6 × 3½ × ·40 7·65	
46	36	30·0	6·0		9·35	7 × 3½ × ·42 10·95	9 × 3½ × ·39 18·65	9 × 3½ × ·51 21·90	10 × 3½ × ·48 26·75	6 × 3½ × ·44 8·20	
48	37	30·0	6·0		7 × 3½ × ·35 9·80	7 × 3½ × ·45 11·50	9 × 3½ × ·43 19·65	9 × 3½ × ·55 23·00	10 × 3½ × ·53 28·45	6 × 3½ × ·47 8·65	
50	38	30·0	6·0		7 × 3½ × ·38 10·25	7 × 3½ × ·47 11·85	9 × 3½ × ·46 20·50	9 × 3½ × ·58 23·85	10 × 3½ × ·57 29·80	6 × 3½ × ·51 9·20	

Section moduli above are given to nearest ·05.

For Notes see page 99.

(27) PEAK FRAMES EXTEND TO U.D. IN DIAGRAM I AND SECOND DK IN DIAGRAM II.
FRAMES IN UPPER TWEEN DK OVER PEAKS (DIAGRAM II) TO BE "C" FOR'D & AFT. ("B" AFT IF NO POOP).
FRAMES OVER PEAKS IN SHIPS INTERMEDIATE BETWEEN DIAGRAMS I AND II TO BE INTERPOLATED.

'TWEEN DECK FRAMING. TABLE 13

NOTES.—TABLE 13.

C IF NO BRIDGE OVER.

SEE NOTE 63 (SECTION 12)

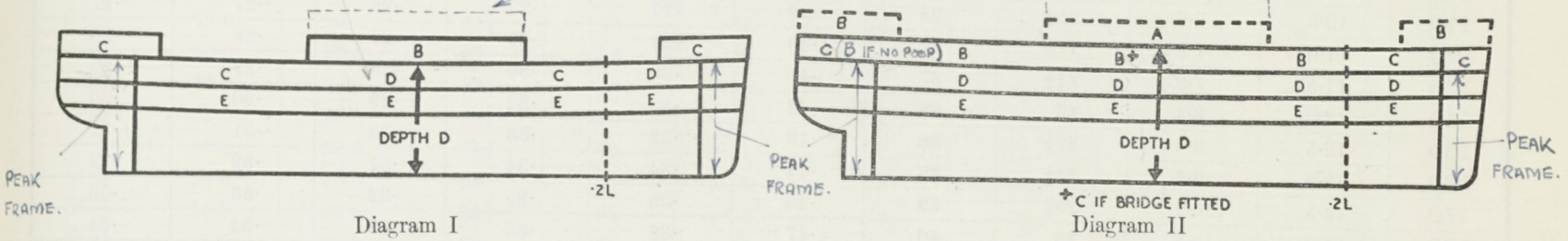


Diagram I

Diagram II

1. **Scantlings.**—The scantlings of the 'tween deck frames are given in Cols. A to F. The positions to which each column between A and E applies are shown in the diagrams; for Col. F *see* Note 3. The scantlings given in the Table apply to frames fitted at every frame.

Diagram I is to be used when the ratio of draught d to depth D exceeds ·75

Diagram II is to be used when the ratio of draught d to depth D is—

less than ·68 when D exceeds 22 feet
„ „ ·60 „ D is 18 feet;
intermediate values to be obtained by interpolation.

When the value of the ratio d/D falls between the limits defined above the scantlings of the framing are to be determined by interpolation.

2. **Corrections to Modulus of Framing.**

For Draught.

If d is $\begin{matrix}\text{greater}\\\text{less}\end{matrix}$ than d_b modulus to be $\begin{matrix}\text{increased}\\\text{reduced}\end{matrix}$ by the percentage given in the Table per foot of difference.

For Frame Spacing.

If the spacing amidships differs from that given in the Table, modulus to be modified in direct proportion. (*See* also **Section 6, clause 2.**)

For 'Tween Deck Height.

If the 'tween deck height at side is greater than 8 feet 6 inches, modulus to be increased in direct proportion.

(15) TWEEN DK FRAME NOT REDUCED WHEN HEIGHT LESS THAN 8'-6"

3. If the framing in a 'tween deck consists of alternate frames extended from below with intermediate frames the mean modulus per frame space is to be as required for uniform framing, but the modulus of the intermediate frames is not to be less than that given in Col. F. If frames are fitted two spaces apart (*see* **Section 6, clause 4** (*a*)) the mean modulus per frame space is to be maintained.

(17) APPLIES TO DETACHED SUPERSTRUCTURE AS WELL AS TWEEN DK. REDUCE Y BY 30% FOR SUPERSTRUCTURE ON SUPERSTRUCTURE.

4. Where several tiers of superstructures are fitted the scantlings and arrangements of the framing will be specially considered.

5. For increase in 'tween deck bunkers *see* **Section 6, clause 6** (*b*).

6. Particulars of sections and moduli are given in **Table 56.**

(14) FRAMES IN DEEP TWEEN DECKS BETWEEN TUNNEL FLAT AND LOWER DECK TO BE TREATED AS HOLD FRAMES, DUE ALLOWANCE BEING MADE FOR POSITION OF CENTRE OF SPAN RELATIVE TO DECK.

WHERE SHORT ERECTIONS, NOT EXTENDING COMPLETELY TO THE STERN OF A SHIP, ARE FITTED AT THE AFTER END THE SCANTLINGS FOR FRAMES MAY BE TAKEN AS FOR A BRIDGE & NOT A POOP BUT THE SCANTLINGS FOR SIDE PLATING MAY BE TAKEN AS FOR A POOP (L.O. 26/1/51)

TABLE 14

(SEE CONTINUATION.)

SHELL PLATING.

LENGTH L	BASIC DEPTH D_b	BASIC DRAUGHT d_b	FRAME SPACING AMIDSHIPS.	WIDTH OF FLAT PLATE KEEL. NOT CORRECTED FOR D or d.	THICKNESS OF FLAT PLATE KEEL.	THICKNESS OF SHELL PLATING FOR ·4L AMIDSHIPS.		THICKNESS OF SIDE AND BOTTOM PLATING FOR ·05L FROM ENDS.	MINIMUM THICKNESS OF SHELL PLATING FOR ·4L AMIDSHIPS.	
						FROM KEEL TO UPPER TURN OF BILGE.	FROM UPPER TURN OF BILGE TO SHEERSTRAKE.		FROM KEEL TO UPPER TURN OF BILGE.	FROM UPPER TURN OF BILGE TO SHEERSTRAKE.
1	2	3	4	5	6	7	8	9	10	11
Feet.	Feet.	Feet.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
100	10·0	6·0	21	36	·38	·26	·26	·25	·26	·26
110	10·5	6·6	21¼	36	·39	·27	·27	·26	·27	·27
120	11·0	7·2	21½	37	·40	·29	·29	·27	·28	·28
130	11·5	7·8	21¾	37	·41	·30	·30	·28	·29	·29
140	12·0	8·4	22	38	·42	·32	·32	·29	·30	·30
150	12·5	9·0	22¼	38	·43	·33	·33	·30	·31	·31
160	13·0	9·6	22½	39	·44	·34	·34	·31	·32	·32
170	13·5	10·2	22¾	39	·45	·35	·35	·32	·33	·33
180	14·0	10·8	23	40	·47	·36	·36	·33	·34	·34
190	15·0	11·4	23¼	40	·48	·37	·37	·34	·35	·35
200	16·0	12·0	23½	41	·50	·38	·38	·34	·36	·36
210	17·0	12·6	23¾	41	·51	·39	·39	·35	·37	·37
220	18·0	13·2	24	42	·52	·40	·40	·35	·38	·38
230	19·0	13·8	24¼	42	·53	·41	·41	·36	·39	·39
240	20·0	14·4	24½	43	·55	·42	·42	·37	·40	·40
250	21·0	15·0	24¾	43	·56	·43	·43	·37	·41	·41
260	22·0	15·6	25	44	·57	·44	·44	·38	·42	·42
270	23·0	16·2	25¼	44	·58	·45	·45	·38	·42	·42
280	24·0	16·8	25½	45	·60	·46	·46	·39	·43	·43
290	25·0	17·4	25¾	45	·61	·47	·47	·39	·43	·43
300	26·0	18·0	26	46	·63	·48	·48	·40	·44	·44
310	27·0	18·6	26¼	46	·64	·49	·49	·40	·44	·44
320	28·0	19·2	26½	47	·66	·50	·50	·41	·45	·45
330	29·0	19·8	26¾	47	·67	·51	·51	·41	·46	·46
340	30·0	20·4	27	48	·69	·52	·52	·42	·47	·47
350	31·0	21·0	27¼	48	·70	·53	·53	·42	·48	·48
360	32·0	21·6	27½	49	·72	·54	·54	·43	·49	·49
370	33·0	22·2	27¾	49	·74	·55	·55	·43	·50	·50
380	34·0	22·8	28	50	·76	·56	·56	·44	·51	·51
390	35·0	23·4	28¼	50	·77	·57	·56	·44	·52	·52
400	36·0	24·0	28½	51	·79	·58	·57	·45	·53	·53
410	37·0	24·6	28¾	51	·80	·59	·58	·45	·54	·54
420	38·0	25·2	29	52	·82	·60	·59	·46	·55	·55
430	39·0	25·8	29¼	52	·83	·61	·60	·46	·56	·56
440	40·0	26·4	29½	53	·85	·63	·61	·47	·57	·57
450	41·0	27·0	29¾	53	·86	·64	·62	·47	·58	·58
460	42·0	27·6	30	54	·88	·66	·63	·48	·59	·59
470	43·0	28·2	30¼	54	·89	·67	·64	·48	·60	·60
480	44·0	28·8	30½	55	·91	·68	·65	·49	·62	·62
490	45·0	29·4	30¾	55	·92	·69	·66	·49	·64	·63
500	46·0	30·0	31	56	·94	·70	·67	·50	·66	·65

For Notes see page 101.

SHELL PLATING. TABLE 14

(CONCLUDED.)

LENGTH L	BASIC DEPTH D_b	BASIC DRAUGHT d_b	FRAME SPACING AMIDSHIPS.	WIDTH OF FLAT PLATE KEEL.	THICKNESS OF FLAT PLATE KEEL.	THICKNESS OF SHELL PLATING FOR ·4L AMIDSHIPS.		THICKNESS OF SIDE AND BOTTOM PLATING FOR ·05L FROM ENDS.	MINIMUM THICKNESS OF SHELL PLATING FOR ·4L AMIDSHIPS.	
						FROM KEEL TO UPPER TURN OF BILGE.	FROM UPPER TURN OF BILGE TO SHEERSTRAKE.		FROM KEEL TO UPPER TURN OF BILGE.	FROM UPPER TURN OF BILGE TO SHEERSTRAKE.
1	2	3	4	5	6	7	8	9	10	11
Feet.	Feet.	Feet.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
510	47·0	30·0	31¼	57	·95	·71	·68	·50	·67	·66
520	48·0	30·0	31½	57	·96	·72	·69	·51	·69	·67
530	49·0	30·0	31¾	58	·97	·73	·70	·51	·70	·68
540	50·0	30·0	32	59	·98	·74	·71	·52	·72	·69
550	51·0	30·0	32¼	59	·99	·75	·71	·52	·73	·69
560	52·0	30·0	32½	60	1·00	·76	·72	·53	·74	·70
570	53·0	30·0	32¾	60	1·01	·77	·73	·53	·75	·71
580	54·0	30·0	33	61	1·03	·78	·74	·54	·76	·72
590	55·0	30·0	33¼	61	1·04	·79	·74	·55	·77	·72
600	56·0	30·0	33½	62	1·06	·80	·75	·56	·78	·73
610	57·0	30·0	33¾	63	1·07	·81	·75	·56	·79	·73
620	58·0	30·0	34	63	1·08	·82	·76	·57	·80	·74
630	59·0	30·0	34¼	64	1·09	·83	·77	·57	·81	·75
640	60·0	30·0	34½	65	1·11	·84	·78	·58	·82	·76
650	61·0	30·0	34¾	65	1·12	·85	·78	·58	·83	·77

(49) KEEL NOT CORRECTED FOR d OR D.

NOTES.—TABLE 14.

1. **Keel.**—The width and thickness of the keel plate (Cols. 5 and 6) are to be maintained throughout.

2. **Garboard Strake.**—If a bar keel is fitted, the thickness of the garboard strake is to be 85 per cent of that required for a keel plate (Col. 6); this thickness is to be maintained for ·4L amidships and may be 85 per cent of the midship thickness for ·05L at the ends, but in way of strengthening of bottom forward is not to be less than required for bottom plating.

3. **Bottom and Side Plating.**—The Table thickness of bottom and side plating for ·4L amidships (Cols. 7 and 8) is to be corrected, if necessary, as follows:—

For Depth.

If D_1 is $\begin{matrix}\text{greater}\\\text{less}\end{matrix}$ than D_b, thickness to be $\begin{matrix}\text{reduced}\\\text{increased}\end{matrix}$ by 0·7 per cent per foot of difference.

For Draught.

If d is $\begin{matrix}\text{greater}\\\text{less}\end{matrix}$ than d_b, thickness to be $\begin{matrix}\text{increased}\\\text{reduced}\end{matrix}$ by 1·5 per cent per foot of difference.

If both these corrections are required the factors derived from each correction are to be multiplied together and not applied separately to the Table thickness. (*Example: Correction for depth* + 1·22%; *correction for draught* — 3·37%; *total factor* 1·012 × ·966 = ·978.)

The thicknesses for ·05 L at ends given in Col. 9 are not subject to the above corrections.

4. **Effective Superstructure.**—If an Effective Superstructure (**Section 2, clause 6**) is fitted the shell plating may be modified as stated in **Section 7, clause 1** (*c*).

5. **Frame Spacing.**—If the spacing amidships differs from the Table spacing (Col. 4) the thickness of bottom and side plating is to be modified at the rate of ·01 inch for every inch of difference.

Where the bottom is framed longitudinally the thickness of the bottom shell plating is to be modified at the same rate for every inch of difference of spacing from that given in **Table 10.**

6. **Minimum Thickness.**—The thickness of the bottom and side plating for ·4L amidships, after correction as required by Notes 3 and 5, is not to be less than that given in Cols. 10 and 11, corrected as required by Note 5 only.

7. **Local Strengthening.**—Plates connected to the sternframe or propeller brackets are to have the thickness given in Col. 8 without corrections and those which require to be furnaced are to be of that thickness when finished.

For strengthening of bottom forward *see* **Section 8, clause 2.**

For strengthening at openings in shell *see* **Section 7, clause 2.**

For strengthening at ends of superstructures *see* **Sections 12, clause 3,** and **13, clause 3.**

For strengthening for navigation in ice *see* **Section 10, clause 3.**

Greenock Dockyard 478 No shell stringers.

Panting beams increased 20% on every frame.

i.e. $\frac{\text{Table beam}}{2} \times 1.20$ at every frame.

TABLE 15

BEAMS IN PEAKS BELOW LOWEST DECK.

(41) NOT CORRECTED FOR FRAME SPACING.

BREADTH B		BEAM A ½y (ex flg)	KNEE	RIVETS	
Feet.		Inches.	Inches.	Number.	Inches.
22	BULB ANGLES	5 ×3 ×·28	15 ×·30	4	¾
26		5 ×3 ×·32	15 ×·32	4	¾
30		5½ ×3 ×·34	16½ ×·34	5	¾
34		6 ×3 ×·36 3.58	18 ×·34	6	¾
38	CHANNELS	6×3 ×3 ×·32 4.07	20 ×·36	6	¾
42		6×3 ×3 ×·42 4.67	22 ×·38	6	⅞
46		7×3 ×3 ×·40 5.16	24 ×·38	6	⅞
50		8×3 ×3 ×·44 5.97	26 ×·40	6	⅞
54		8×3½×3½×·40 6.58 16.0	28 ×·42	7	⅞
58		9×3½×3½×·44 7.45 19.7	30 ×·44	7	⅞
62		10×3½×3½×·48 8.39 23.9	32 ×·46	8	⅞
66		10×3½×3½×·56 9.19 25.25	34 ×·48	8	⅞
70		12×4 ×4 ×·48 10.17 35.3	36 ×·50	9	⅞

TABLE 16

STRINGERS IN PANTING REGION.

LENGTH L	FORWARD OF COLLISION BULKHEAD.		ABAFT COLLISION BULKHEAD.	
	STRINGER PLATE.		THICKNESS OF INTERCOSTAL PLATE.	FACE ANGLE. S.A
	✗ WIDTH.	THICKNESS.		
Feet.	Inches.	Inches.	Inches.	Inches.
100	22	·26	·28	ANGLES: $2\frac{1}{2} \times 2\frac{1}{2} \times ·30$ 1·41
200	25	·29	·31	ANGLES: 3 ×3 ×·36 2·03
300	28	·32	·35	ANGLES: $4\frac{1}{2} \times 3$ ×·40 2·84
400	32	·35	·39	ANGLES: 6 $\times 3\frac{1}{2} \times ·42$ 3·81
500	36	·38	·42	BULB ANGLES: 7 $\times 3\frac{1}{2} \times ·42$ 4·86
600	40	·41	·46	BULB ANGLES: 8 $\times 3\frac{1}{2} \times ·48$ 6·05

✗ (83) TABLE WIDTH MAY BE REDUCED BY 2" FOR EACH 1 FT REDUCTION IN STRINGER SPACING.

TABLE 17

ICE STRENGTHENING: INTERMEDIATE FRAMES.

(42) NOT CORRECTED FOR FRAME SPACING.

LENGTH L	INTERMEDIATE FRAME.	
	FORWARD OF COLLISION BULKHEAD.	ABAFT COLLISION BULKHEAD.
Feet.	Inches.	Inches.
200	ANGLES: 3 ×3 ×·36 1·20	ANGLE: 5 ×3×·42 3·48
250	ANGLES: $3\frac{1}{2} \times 3$ ×·40 1·73	BULB ANGLES: 5 ×3×·36 4·75
300	ANGLES: 4 ×3 ×·48 2·63	BULB ANGLES: $5\frac{1}{2} \times 3 \times ·40$ 6·25
350	ANGLES: 5 ×3 ×·46 3·80	BULB ANGLES: 6 ×3×·42 7·90
400	ANGLES: 6 $\times 3\frac{1}{2} \times ·44$ 5·18	BULB ANGLES: $7 \times 3\frac{1}{2} \times ·36$ 9·95
450	ANGLES: 7 $\times 3\frac{1}{2} \times ·44$ 6·94	BULB ANGLES: $7 \times 3\frac{1}{2} \times ·50$ 12·45.

TABLE 18

(SEE CONTINUATION.)

TOPSIDE SCANTLINGS.

LENGTH L	BASIC BREADTH B_b	BASIC DEPTH D_b	BASIC DRAUGHT d_b	BEAM SPACING AMIDSHIPS.	WIDTH OF SHEERSTRAKE AND STRINGER PLATE OF PLATED DECK.	THICKNESS OF SHEERSTRAKE FOR ·4L AMIDSHIPS.	SECTIONAL AREAS OF STRENGTH DECK FOR ·4L AMIDSHIPS AND CORRECTIONS FOR DEPTH, DRAUGHT AND BEAM. (Col.17)		
							WHERE ONE DECK FITTED.		
							SECTIONAL AREA.	*CORRECTION PER 1 FOOT DIFFERENCE BETWEEN*	
								D *and* D_b	d *and* d_b
1	2	3	4	5	6	7	8	9	10
Feet.	Feet.	Feet.	Feet.	Inches.	Inches.	Inches.	Square Inches.	Per Cent.	Per Cent.
100	25	10	6·0	21	42	·28	7	*18·40*	*21·00*
110	26	10·5	6·6	21¼	42	·29	8	*15·90*	*20·10*
120	27	11	7·2	21½	43	·30	10	*14·30*	*19·20*
130	28	11·5	7·8	21¾	44	·32	11	*13·15*	*18·40*
140	29	12	8·4	22	45	·34	13	*12·25*	*17·60*
150	30	12·5	9·0	22¼	45	·36	16	*11·45*	*16·70*
160	31	13	9·6	22½	46	·37	19	*10·80*	*15·90*
170	32	13·5	10·2	22¾	46	·38	22	*10·20*	*15·10*
180	33	14	10·8	23	47	·40	25	*9·70*	*14·30*
190	34	15	11·4	23¼	48	·41	27	*9·25*	*13·55*
200	35	16	12·0	23½	49	·43	29	*8·80*	*12·80*
210	36	17	12·6	23¾	50	·44	32	*8·40*	*12·10*
220	37	18	13·2	24	51	·45	35	*8·00*	*11·40*
230	38	19	13·8	24¼	51	·46	38	*7·70*	*10·75*
240	39	20	14·4	24½	52	·47	42	*7·40*	*10·10*
250	40	21	15·0	24¾	52	·48	46	*7·20*	*9·50*
260	41	22	15·6	25	53	·50	51	*6·95*	*8·95*
270	42	23	16·2	25¼	53	·51	56	*6·70*	*8·45*
280	43	24	16·8	25½	54	·53	62	*6·50*	*7·90*
290	44	25	17·4	25¾	54	·54	68	*6·35*	*7·50*
300	45	26	18·0	26	55	·55	75	*6·15*	*7·10*
310	46	27	18·6	26¼	55	·56	81	*6·00*	*6·70*
320	47	28	19·2	26½	56	·57	88	*5·85*	*6·30*
330	48	29	19·8	26¾	56	·58	95	*5·70*	*5·95*
340	49	30	20·4	27	57	·59	102	*5·55*	*5·60*
350	50	31	21·0	27¼	57	·60	110	*5·40*	*5·30*
360	51	32	21·6	27½	58	·61	118	*5·25*	*5·05*
370	52	33	22·2	27¾	58	·63	126	*5·10*	*4·80*
380	53	34	22·8	28	59	·64	134	*4·95*	*4·60*
390	54	35	23·4	28¼	59	·65	143	*4·80*	*4·45*
400	55	36	24·0	28½	60	·67	152	*4·70*	*4·30*
410	56	37	24·6	28¾	60	·68	162	*4·55*	*4·20*
420	57	38	25·2	29	61	·70	172	*4·40*	*4·15*
430	58	39	25·8	29¼	61	·71	182	*4·30*	*4·10*
440	59	40	26·4	29½	62	·73	192	*4·20*	*4·05*
450	60	41	27·0	29¾	62	·74	203	*4·10*	*4·00*
460	61	42	27·6	30	63	·75			
470	62	43	28·2	30¼	63	·76			
480	63	44	28·8	30½	64	·78			
490	64	45	29·4	30¾	64	·79			
500	65	46	30·0	31	65	·80			

For Notes see pages 106 & 107.

(36) IF L OUTSIDE TABLE (i.e. LESS THAN SMALLEST TABLE VALUE)
DO NOT EXTRAPOLATE BUT TAKE AS FOR 2 DECK SHIP WITH 2ND OR 3RD DECK PLATFORM.

TOPSIDE SCANTLINGS.

TABLE 18

(SEE CONTINUATION.)

SECTIONAL AREA OF STRENGTH DECK FOR ·4L AMIDSHIPS AND CORRECTIONS FOR DEPTH, DRAUGHT AND BEAM.						MINIMUM THICKNESS OF UNSHEATHED PLATING OF STRENGTH DECK FOR ·4L AMIDSHIPS.		THICKNESS OF UNSHEATHED PLATING OF STRENGTH DECK FOR ·1L FROM ENDS.		LENGTH L
WHERE TWO DECKS FITTED.			WHERE THREE DECKS FITTED.							
SECTIONAL AREA.	*CORRECTION PER 1 FOOT DIFFERENCE BETWEEN:* D *and* D_b	*CORRECTION PER 1 FOOT DIFFERENCE BETWEEN:* d *and* d_b	SECTIONAL AREA.	*CORRECTION PER 1 FOOT DIFFERENCE BETWEEN:* D *and* D_b	*CORRECTION PER 1 FOOT DIFFERENCE BETWEEN:* d *and* d_b	ALL STRENGTH DECKS *CORRECTION PER 1 FOOT DIFFERENCE BETWEEN* B *and* B_b	OUTSIDE LINE OF OPENINGS.	INSIDE LINE OF OPENINGS.	STRINGER.	PLATING.	
11	12	13	14	15	16	17	18	19	20	21	22
Square Inches.	Per Cent.	Per Cent.	Square Inches.	Per Cent.	Per Cent.	Per Cent.	Inches.	Inches.	Inches.	Inches.	Feet.
						4·0	·26	·26	·26	·26	100
						4·0	·26	·26	·26	·26	110
						4·0	·27	·26	·27	·26	120
						4·0	·27	·27	·27	·26	130
						4·0	·28	·27	·28	·26	140
						4·0	·28	·27	·28	·26	150
						4·0	·29	·28	·29	·27	160
X						*4·0*	·30	·28	·29	·27	170
23	*13·65*	*11·20*				*4·0*	·31	·28	·30	·27	180
25	*13·10*	*11·05*				*4·0*	·31	·28	·30	·27	190
27	*12·50*	*10·90*				*4·0*	·32	·29	·31	·28	200
29	*12·00*	*10·70*				*4·0*	·32	·29	·31	·28	210
31	*11·50*	*10·50*				*4·0*	·33	·29	·32	·28	220
34	*11·00*	*10·35*				*4·0*	·33	·29	·32	·28	230
37	*10·55*	*10·15*				*4·0*	·34	·30	·33	·29	240
40	*10·05*	*9·95*				*4·0*	·34	·30	·33	·29	250
44	*9·60*	*9·70*				*4·0*	·35	·31	·34	·29	260
48	*9·25*	*9·45*				*4·0*	·35	·31	·34	·29	270
52	*8·95*	*9·20*				*4·0*	·36	·32	·35	·30	280
56	*8·70*	*8·85*				*4·0*	·36	·32	·35	·30	290
61	*8·45*	*8·50*				*4·0*	·37	·33	·36	·30	300
66	*8·20*	*8·05*				*3·9*	·37	·33	·36	·30	310
72	*8·00*	*7·60*				*3·8*	·38	·34	·37	·31	320
77	*7·80*	*7·15*	X			*3·7*	·38	·34	·37	·31	330
82	*7·65*	*6·75*	78	*9·50*	*7·05*	*3·6*	·39	·34	·38	·31	340
88	*7·50*	*6·40*	84	*9·10*	*6·70*	*3·5*	·39	·34	·38	·31	350
94	*7·30*	*6·05*	90	*8·70*	*6·35*	*3·4*	·40	·35	·39	·32	360
101	*7·10*	*5·70*	96	*8·35*	*6·05*	*3·3*	·40	·35	·39	·32	370
108	*6·90*	*5·45*	102	*8·05*	*5·75*	*3·2*	·41	·35	·39	·32	380
115	*6·75*	*5·20*	108	*7·80*	*5·50*	*3·1*	·41	·35	·39	·32	390
122	*6·60*	*5·00*	115	*7·55*	*5·30*	*3·0*	·42	·36	·40	·33	400
129	*6·40*	*4·80*	123	*7·35*	*5·10*	*2·9*	·43	·36	·40	·33	410
137	*6·20*	*4·65*	131	*7·20*	*4·95*	*2·8*	·44	·36	·40	·33	420
145	*6·00*	*4·50*	139	*7·05*	*4·80*	*2·7*	·44	·36	·40	·33	430
153	*5·85*	*4·40*	146	*6·95*	*4·70*	*2·6*	·45	·37	·41	·34	440
162	*5·70*	*4·30*	153	*6·80*	*4·55*	*2·5*	·45	·37	·41	·34	450
171	*5·50*	*4·20*	161	*6·70*	*4·45*	*2·4*	·46	·37	·41	·34	460
180	*5·30*	*4·15*	169	*6·60*	*4·40*	*2·3*	·46	·37	·41	·34	470
190	*5·10*	*4·10*	176	*6·50*	*4·30*	*2·2*	·47	·38	·42	·34	480
200	*4·95*	*4·05*	184	*6·40*	*4·25*	*2·1*	·47	·38	·42	·34	490
210	*4·80*	*4·00*	192	*6·30*	*4·20*	*2·0*	·48	·38	·42	·35	500

For Notes see pages 106 and 107.

TABLE 18
(CONCLUDED.)

TOPSIDE SCANTLINGS.

LENGTH L	BASIC BREADTH B_b	BASIC DEPTH D_b	BASIC DRAUGHT d_b	BEAM SPACING AMIDSHIPS.	WIDTH OF SHEERSTRAKE AND STRINGER PLATE OF PLATED DECK.	THICKNESS OF SHEERSTRAKE FOR ·4L AMIDSHIPS.	SECTIONAL AREAS OF STRENGTH DE FOR ·4L AMIDSHIPS AND CORRECTI FOR DEPTH, DRAUGHT AND BEAM. (Col WHERE ONE DECK FITTED.		
							SECTIONAL AREA.	*CORRECTION PER 1 DIFFERENCE BETW* D *and* D_b	d *and*
1	2	3	4	5	6	7	8	9	10
Feet.	Feet.	Feet.	Feet.	Inches.	Inches.	Inches.	Square Inches.	Per Cent.	Per C
510	66	47	30·0	$31\frac{1}{4}$	65	·81			
520	67	48	30·0	$31\frac{1}{2}$	66	·82			
530	68	49	30·0	$31\frac{3}{4}$	66	·82			
540	69	50	30·0	32	67	·83			
550	70	51	30·0	$32\frac{1}{4}$	67	·84			
560	71	52	30·0	$32\frac{1}{2}$	68	·85			
570	72	53	30·0	$32\frac{3}{4}$	68	·85			
580	73	54	30·0	33	69	·86			
590	74	55	30·0	$33\frac{1}{4}$	69	·87			
600	75	56	30·0	$33\frac{1}{2}$	70	·87			
610	76	57	30·0	$33\frac{3}{4}$	71	·88			
620	77	58	30·0	34	72	·89			
630	78	59	30·0	$34\frac{1}{4}$	73	·89			
640	79	60	30·0	$34\frac{1}{2}$	74	·90			
650	80	61	30·0	$34\frac{3}{4}$	75	·90			

(28) SHEERSTRAKE MAY BE REDUCED IN THICKNESS IF BREADTH GREATER THAN TABLE, PROVIDED IT IS NOT LESS THAN MINIMUM SIDE SHELL & BEARS A REASONABLE RELATION TO THE THICKNESS OF DECK STRINGER.

IN SMALL SHIPS, IF THE DECK AREA EXCEEDS RULE AREA, SHEERSTRAKE MAY BE REDUCED SUBJECT TO THE ABOVE LIMITATIONS.

NOTES.—TABLE 18.

1. **Sheerstrake.**—(*a*) The Table thickness of the sheerstrake (Col. 7) is to be corrected, if necessary, as follows:—

FOR DEPTH.

If D is $\begin{matrix}\text{greater}\\\text{less}\end{matrix}$ than D_b, thickness to be $\begin{matrix}\text{reduced}\\\text{increased}\end{matrix}$ by 4 per cent per foot of difference.

FOR DRAUGHT.

If d is $\begin{matrix}\text{greater}\\\text{less}\end{matrix}$ than d_b, thickness to be $\begin{matrix}\text{increased}\\\text{reduced}\end{matrix}$ by 4 per cent per foot of difference.

If both corrections are required the factors derived from each correction are to be multiplied together and not applied separately to the Table thickness. (*Example: Correction for depth* +7·32%; *correction for draught* −10·16%; *total factor* =1·073×·898=·964.)

(*b*) The thickness of sheerstrake is not to be corrected for frame spacing, but is not to be less, for ·4L amidships, than the side plating. ·05 L

The thickness of sheerstrake at ends is to be the same as that of the side plating except in ships in which the draught does not exceed ·7D (D being measured to the uppermost continuous deck) when the end thickness may be as required for a poop or forecastle aft or forward respectively.

2. **Plated Strength Deck.**—(*a*) The Table area of the strength deck (Cols. 8, 11 and 14) is for one side of the ship outside the line of hatchways or other openings. The area includes the stringer plate, deck plating and overlapped seams, if fitted, but not the stringer angle. If the stringer angle is omitted the deck area is to be correspondingly increased.

(*b*) The Table area (Cols. 8, 11 and 14) is to be corrected, if necessary, as follows:—

FOR DEPTH.

If D is $\begin{matrix}\text{greater}\\\text{less}\end{matrix}$ than D_b, area to be $\begin{matrix}\text{reduced}\\\text{increased}\end{matrix}$ by the given percentage (Cols. 9, 12 and 15) per foot of difference.

FOR DRAUGHT.

If d is $\begin{matrix}\text{greater}\\\text{less}\end{matrix}$ than d_b, area to be $\begin{matrix}\text{increased}\\\text{reduced}\end{matrix}$ by the given percentage (Cols. 10, 13 and 16) per foot of difference.

FOR BREADTH.

If B is $\begin{matrix}\text{greater}\\\text{less}\end{matrix}$ than B_b, area to be $\begin{matrix}\text{increased}\\\text{reduced}\end{matrix}$ by the given percentage (Col. 17) per foot of difference.

If more than one of the above corrections is required the factors derived from the individual corrections are to be multiplied together and not applied separately to the Table area. (Example: *Correction for depth* — 13·81%; *correction for draught* + 3·92%; *correction for breadth* + 9·12%; *total factor* = ·862 × 1·039 × 1·091 = ·978.)

3. **Longitudinal Framing.**—Where the deck is framed longitudinally, the thickness of the plating may be reduced over the midships ·4L by ·03 inch at a length of 300 feet and ·05 inch at 500 feet or above with a proportionate reduction at intermediate lengths.

(44) REDUCTION FOR LONGITUDINAL FRAMING ONLY APPLIES OUTSIDE LINE OF OPENINGS.

---- BUT NOT REDUCED BY 10% AS PER NOTE 2 TO TABLE 21. (L.O. 12/4/48)

(53) IF U.DK. AREA OF 2 DECK SHIP, BASED ON MINIMUM THICKNESS, EQUALS REQUIREMENTS FOR SINGLE DECK SHIP SECOND DECK CAN BE NON-RULE.

TOPSIDE SCANTLINGS.

TABLE 18
(CONCLUDED.)

SECTIONAL AREAS OF STRENGTH DECK FOR ·4L AMIDSHIPS AND CORRECTIONS FOR DEPTH, DRAUGHT AND BEAM.							MINIMUM THICKNESS OF UNSHEATHED PLATING OF STRENGTH DECK FOR ·4L AMIDSHIPS.		THICKNESS OF UNSHEATHED PLATING OF STRENGTH DECK FOR ·1L FROM ENDS.		LENGTH L
WHERE TWO DECKS FITTED.			WHERE THREE DECKS FITTED.			ALL STRENGTH DECKS					
SECTIONAL AREA.	CORRECTION PER 1 FOOT DIFFERENCE BETWEEN: D and D_b	CORRECTION PER 1 FOOT DIFFERENCE BETWEEN: d and d_b	SECTIONAL AREA.	CORRECTION PER 1 FOOT DIFFERENCE BETWEEN: D and D_b	CORRECTION PER 1 FOOT DIFFERENCE BETWEEN: d and d_b	CORRECTION PER 1 FOOT DIFFERENCE BETWEEN B and B_b	OUTSIDE LINE OF OPENINGS.	INSIDE LINE OF OPENINGS.	STRINGER.	PLATING.	
11	12	13	14	15	16	17	18	19	20	21	22
Square Inches.	Per Cent.	Per Cent.	Square Inches.	Per Cent.	Per Cent.	Per Cent.	Inches.	Inches.	Inches.	Inches.	Feet.
218	4·55	4·00	200	5·95	4·20	2·0	·48	·38	·42	·35	510
227	4·30	4·00	208	5·55	4·20	2·0	·49	·39	·43	·35	520
236	4·05	4·00	216	5·20	4·20	2·0	·49	·39	·43	·35	530
245	3·80	4·00	224	4·90	4·20	2·0	·50	·39	·43	·35	540
254	3·60	4·00	232	4·60	4·20	2·0	·50	·39	·43	·35	550
262	3·45	4·00	240	4·35	4·20	2·0	·50	·40	·44	·36	560
			248	4·10	4·20	2·0	·50	·40	·44	·36	570
			256	3·85	4·20	2·0	·50	·40	·44	·36	580
			264	3·65	4·20	2·0	·50	·40	·44	·36	590
			272	3·50	4·20	2·0	·50	·41	·45	·36	600
			280	3·35	4·20	2·0	·50	·41	·45	·36	610
			288	3·25	4·20	2·0	·50	·41	·45	·37	620
			296	3·15	4·20	2·0	·50	·41	·45	·37	630
			304	3·10	4·20	2·0	·50	·42	·46	·37	640
			313	3·00	4·20	2·0	·50	·42	·46	·37	650

(47) IF L LESS THAN 350' NO REDUCTION IN STRENGTH DECK AREA IF HEIGHT OF UPPER TWEEN DK LESS THAN 8'·6". IF L EXCEEDS 350', REDUCTION OF 4% PER FOOT BELOW 8'·6"

(50) IF SECOND TW. DK HEIGHT EXCEEDS 8'·6", AREA OF 3RD DK TO BE INCREASED SO THAT ITS MOMENT ABOUT ASSUMED N.A. IS THE SAME AS THAT OF A 3RD DK 8'·6" BELOW 2ND DK.

(56) TW. DK HT CORR^N CORRECT FOR L/D = 14 T.D. HT UP TO 11'·0 EXTREME CASES TO BE CONSIDERED ON THEIR MERITS.

NOTES.—TABLE 18 (*continued*).

4. **'Tween Deck Height.**—If the midship height of the 'tween decks below the strength deck exceeds 8 feet 6 inches at side, the area of the strength deck, corrected as required by Note 2 (*b*), is to be increased by 5% per cent per foot increase in 'tween deck height. If the second 'tween deck height exceeds 8 feet 6 inches a further increase may be required. (81) IF 2ND DK AREA IS EXCESS, AREA OF UPPER DK MAY BE ADJUSTED.

SEE ART. 1957

(32) CORR^N FOR BEAM SPACING ONLY APPLIES WHERE SPACING IS LESS THAN 6" IN EXCESS OF TABLE. FOR BEAMS AT ALTERNATE FRAMES USE PRESENT PRACTICE.

5. **Beam Spacing.**—If the spacing of beams amidships differs from that given in Col. 5, or with longitudinal framing that given in **Table 26,** the minimum thickness of deck plating (Cols. 18 ~~and 19~~) is to be modified at the rate of ·01 inch for every 2 inches of difference, & THAT IN COL 19 BY ·01" FOR EACH COMPLETE 4"

6. **Stringer Plates.**—The thickness of strength deck stringer plates amidships is not to be less than 85 per cent of the thickness of sheerstrake, corrected as required by Note 1, nor less than ·04 inch greater than that given in Col. 18.

(54) IF DK PLATED FORWARD & AFT OF AMIDSHIPS, DECK STRINGER PLATING MAY BE 80% OF SHEERSTRAKE, UNLESS NO STRINGER IS FITTED WHEN MEAN THICKNESS MUST BE AT LEAST 85%.

The width of stringer plates for ·1L at ends is not to be less than 60 per cent of the width amidships (Col. 6).

7. **Stringer Angles.**—Scantlings are to be in accordance with **Table 19.**

8. **Sheathed Decks.**—Where plated decks are sheathed with wood or approved composition the thickness given in Col. 18 may be reduced by 15 per cent in ships over 170 feet in length and by 10 per cent in smaller ships, and that given in Cols. 19, 20 and 21 may be reduced by 10 per cent for all ships.

9. **Effective Superstructures.**—If an Effective Superstructure (**Section 2, clause 6**) is fitted amidships the scantlings of the upper and second decks in way of the superstructure are to be those required for the second and third decks respectively.

10. **Strength Deck with Stringer and Tie Plates.**—Stringer and tie plates fitted under a wood deck are to have the combined sectional area, for ·4L amidships, required for a plated deck.

(39) NO LIMIT, EXCEPT PRACTICAL CONSIDERATIONS, TO SIZE OF SHIP HAVING STRINGERS & TIES.

The width of stringer plates for ·4L amidships is not to be less than 22 inches and 54 inches for lengths of 100 feet and 260 feet respectively with intermediate values in proportion. The width for ·1L from the ends is not to be less than 60 per cent of the width amidships.

The width of tie plates throughout is not to be less than 12 inches and 20 inches for lengths of 100 feet and 260 feet respectively with intermediate values in proportion.

The thickness of the stringer and tie plates is not to be less than given in Col. 20, but stringer plates for ·4L amidships are not to be less than 85 per cent of the Rule thickness of sheerstrake.

11. **Local Strengthening.**—For strengthening at the ends of superstructures *see* **Section 12, clause 3.**

For strengthening at openings *see* **Section 11, clause 5.**

For strengthening in ships having concentrated loading amidships *see* **Section 11, clause 4.**

313† (45) IF L EXCEEDS 170', TABLE 18, COL 18, CORRECTED FOR SPACING, MAY BE REDUCED 15% IF COMPO 2" THICK, & 5% IF 1" IN THICKNESS. ALL OTHER CASES – 10% AT 2" & 5% AT 1" THICK. BELOW 1" NO REDUCTION, AND BETWEEN 1" & 2" PERCENTAGE TO BE INTERPOLATED.

See Mr Bolwell re this

TABLE 19

STRINGER ANGLES ON STRENGTH DECKS

THICKNESS OF SHEERSTRAKE OR STRINGER PLATE WHICHEVER IS THE GREATER.			DIAMETER OF RIVET AS REQUIRED BY TABLE 52	SIZES OF FLANGES.*	SPACING OF RIVETS.	ERUN. THKS OF RIVETING
Above	Inches. and	not exceeding	Inches.	Inches.	Diameters.	
—		·36	$\frac{5}{8}$	3 × 3	$4\frac{1}{2}$	
·36	„	·50	$\frac{3}{4}$	$3\frac{1}{2}$ × $3\frac{1}{2}$	$4\frac{1}{2}$	·13
·50	„	·56	$\frac{7}{8}$	$3\frac{1}{2}$ × $3\frac{1}{2}$	$4\frac{1}{2}$	·15
·56	„	·64	$\frac{7}{8}$	$3\frac{1}{2}$ × $3\frac{1}{2}$	$4\frac{1}{2}$	·15
·64	„	·72	$\frac{7}{8}$	5 × 5	2 rows, 6 in each row	·228
·72	„	·94	1	6 × 6	2 „ $5\frac{1}{2}$ „	·25
·94	„	1·14	$1\frac{1}{8}$	7 × 7	2 „ $5\frac{1}{2}$ „	·25
1·14	„	1·20	$1\frac{1}{4}$	8 × 8	2 „ 5 „	·274

* The thickness of the Stringer Angle is to be that of the Sheerstrake or Stringer Plate, whichever is less.

TABLE 20

(SEE CONTINUATION.)

LOWER DECKS.

LENGTH L	BASIC BREADTH B_b	BEAM SPACING AMIDSHIPS.	SECOND DECK PLATING OUTSIDE LINE OF OPENINGS FOR ·4L AMIDSHIPS.		THIRD DECK PLATING OUTSIDE LINE OF OPENINGS FOR ·4L AMIDSHIPS.		PLATING OF SECOND & THIRD DECKS INSIDE LINE OF OPENINGS & FOR ·1L FROM ENDS AND OF PLATFORM DECKS THROUGHOUT (UNSHEATHED.)
			SECTIONAL AREA.	MINIMUM THICKNESS (UNSHEATHED.)	SECTIONAL AREA.	MINIMUM THICKNESS (UNSHEATHED.)	
1	2	3	4	5	6	7	8
Feet.	Feet.	Inches.	Square Inches.	Inches.	Square Inches.	Inches.	Inches.
180	33	23	16	·28			·26
190	34	23¼	17	·28			·26
200	35	23½	18	·29			·26
210	36	23¾	19	·29			·26
220	37	24	21	·29			·26
230	38	24¼	23	·29			·26
240	39	24½	25	·30			·26
250	40	24¾	28	·30			·26
260	41	25	31	·30			·26
270	42	25¼	35	·30			·26
280	43	25½	38	·31			·26
290	44	25¾	42	·31			·26
300	45	26	46	·31			·26
310	46	26¼	50	·31			·26
320	47	26½	53	·32			·27
330	48	26¾	56	·32			·27
340	49	27	59	·32	53	·29	·27
350	50	27¼	62	·32	55	·29	·27
360	51	27½	64	·33	57	·30	·28
370	52	27¾	66	·33	59	·30	·28
380	53	28	68	·33	61	·30	·28
390	54	28¼	70	·33	63	·30	·28
400	55	28½	72	·34	65	·31	·29
410	56	28¾	75	·34	67	·31	·29
420	57	29	77	·34	69	·31	·29
430	58	29¼	80	·34	71	·31	·29
440	59	29½	82	·35	73	·32	·30
450	60	29¾	85	·35	75	·32	·30
460	61	30	88	·35	77	·32	·30
470	62	30¼	91	·36	79	·32	·30
480	63	30½	94	·36	82	·33	·30
490	64	30¾	97	·36	84	·33	·30
500	65	31	100	·37	87	·33	·31

For Notes see page 111.

LOWER DECKS.

TABLE 20 (CONCLUDED.)

LENGTH L.	BASIC BREADTH B_b	BEAM SPACING AMIDSHIPS.	SECOND DECK PLATING OUTSIDE LINE OF OPENINGS FOR ·4L AMIDSHIPS.		THIRD DECK PLATING OUTSIDE LINE OF OPENINGS FOR ·4L AMIDSHIPS.		PLATING OF SECOND & THIRD DECKS INSIDE LINE OF OPENINGS & FOR ·1L FROM ENDS AND OF PLATFORM DECKS THROUGHOUT (UNSHEATHED.)
			SECTIONAL AREA.	MINIMUM THICKNESS (UNSHEATHED.)	SECTIONAL AREA.	MINIMUM THICKNESS (UNSHEATHED.)	
1	2	3	4	5	6	7	8
Feet.	Feet.	Inches.	Square Inches.	Inches.	Square Inches.	Inches.	Inches.
510	66	$31\frac{1}{4}$	104	·37	90	·34	·31
520	67	$31\frac{1}{2}$	107	·38	93	·34	·31
530	68	$31\frac{3}{4}$	110	·38	96	·34	·31
540	69	32	113	·39	99	·35	·31
550	70	$32\frac{1}{4}$	117	·39	102	·35	·31
560	71	$32\frac{1}{2}$	120	·40	105	·36	·32
570	72	$32\frac{3}{4}$	123	·40	107	·36	·32
580	73	33	126	·41	110	·37	·32
590	74	$33\frac{1}{4}$	129	·41	112	·37	·32
600	75	$33\frac{1}{2}$	132	·42	115	·38	·32
610	76	$33\frac{3}{4}$	135	·42	118	·38	·32
620	77	34	139	·43	121	·39	·33
630	78	$34\frac{1}{4}$	142	·43	124	·39	·33
640	79	$34\frac{1}{2}$	145	·44	128	·40	·33
650	80	$34\frac{3}{4}$	148	·44	132	·40	·33

NOTES.—TABLE 20.

SEE (45) (TABLE 18, NOTE 8)

1. **Sectional Area.**—The Table area of lower decks (Cols. 4 and 6) is for one side of the ship outside the line of hatchways or other openings and inside the line of notches for 'tween deck frames; it includes overlapped seams, if fitted.

(75) NO REDUCTION TO 2ND DK FOR LONG'L FRAMING.

2. **Corrections.**

FOR BREADTH.

If B differs from B (Col. 2) the area is to be modified in direct proportion.

(8) NO MODIFICATION IN Y OF 27" & 24" SPACING.

FOR BEAM SPACING. HT

If the spacing of beams fitted at every frame, or of longitudinals, differs from that in Col. 3 the minimum thickness of deck plating (Cols. 5 and 7) is to be modified at the rate of ·01 inch for every 2 inches of difference.

(21) DECK THICKNESSES COL 8 SHOULD BE CREASED AT THE RATE ·01 FOR EVERY PLETE 4" INCREASE OF EAM SPACING.

3. **Stringer Plates and Angles.**—The thickness of stringer plates may be the same as that of the deck plating. Angles connecting the deck to shell plating are to have the same thickness as the stringer or deck plating to which they are attached.

4. **Sheathed Decks.**—Where plated decks are sheathed with wood or approved composition the thickness given in Cols. 5, 7 and 8 may be reduced by 10 per cent.

(39) NO LIMIT, EXCEPT PRACTICAL CONSIDERATIONS, TO SIZE OF SHIP HAVING STRINGERS & TIES.

5. **Decks with Stringer and Tie Plates.**—Stringer and tie plates fitted under a wood deck are to have the combined sectional area, for ·4L amidships, required for a plated deck.

The width of stringer plates from shell to inner edge, for ·4L amidships, is not to be less than 38 inches and 46 inches for lengths of 180 feet and 260 feet respectively with intermediate values in proportion. The width for ·1L from the ends is not to be less than 60 per cent of the width amidships.

The width of tie plates throughout is not to be less than 12 inches and 20 inches for lengths of 180 feet and 260 feet respectively with intermediate values in proportion.

The thickness of the stringer and tie plates throughout is not to be less than given in Col. 5.

(32) CORR'N FOR BEAM SPACING ONLY APPLIES WHERE SPACING IS LESS THAN 6" IN EXCESS OF TABLE.
FOR BEAMS AT ALTERNATE FRAMES USE PRESENT PRACTICE.

TABLE 21

(SEE CONTINUATION.)

SHORT SUPERSTRUCTURES.

LENGTH L	SIDE PLATING.		WIDTH OF STRINGER AND TIE PLATES WITH WOOD DECK.		THICKNESS OF STRINGER AND TIE PLATES WITH WOOD DECK.			MINIMUM THICKNESS OF UNSHEATHED PLATED DECKS.		
	POOP	BRIDGE & FORECASTLE	STRINGER	TIE PLATE	POOP	BRIDGE	FORECASTLE	POOP	BRIDGE	FORECASTLE.
1	2	3	4	5	6	7	8	9	10	11
Feet.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
100	·22	·22	12	5	·22	·22	·22	·24	·24	·24
110	·22	·22	13	5	·22	·22	·22	·24	·24	·24
120	·22	·22	14	5	·22	·22	·22	·24	·24	·24
130	·22	·22	15	5	·22	·22	·22	·24	·24	·24
140	·23	·23	16	5	·23	·23	·23	·24	·24	·24
150	·23	·24	17	5	·23	·24	·24	·24	·24	·24
160	·24	·25	18	6	·24	·25	·25	·25	·25	·25
170	·24	·25	19	6	·24	·25	·25	·25	·25	·25
180	·25	·26	20	6	·25	·26	·26	·25	·25	·25
190	·25	·27	21	6	·25	·27	·27	·25	·25	·25
200	·26	·28	22	7	·26	·28	·28	·26	·26	·26
210	·26	·28	23	7	·26	·28	·28	·26	·26	·26
220	·27	·29	24	7	·27	·29	·29	·26	·26	·26
230	·27	·29	25	7	·27	·29	·29	·26	·26	·26
240	·28	·30	26	8	·28	·30	·30	·26	·27	·27
250	·28	·30	26	8	·28	·30	·30	·26	·27	·27
260	·29	·31	27	8	·29	·31	·31	·26	·27	·27
270	·29	·32	28	8	·29	·32	·32	·26	·27	·27
280	·30	·33	29	8	·30	·33		·27	·28	·28
290	·30	·33	29	8	·30	·33		·27	·28	·28
300	·31	·34	30	8	·31	·34		·27	·28	·28
310	·31	·35	31	8	·31	·35		·27	·28	·28
320	·32	·36	32	9	·32	·36		·27	·29	·29
330	·32	·36	32	9	·32	·36		·27	·29	·29
340	·33	·37	33	9	·33	·37		·28	·29	·29
350	·33	·37	33	9	·33	·37		·28	·29	·29
360	·34	·38	34	9	·34	·38		·28	·30	·30
370	·34	·38	34	9	·34	·38		·28	·30	·30
380	·35	·39	35	9	·35	·39		·28	·30	·30
390	·35	·39	35	9	·35	·39		·28	·30	·30
400	·36	·40	36	10	·36			·28	·31	·31
410	·36	·40	36	10	·36			·28	·31	·31
420	·37	·41	37	10	·37			·29	·31	·31
430	·37	·41	37	10	·37			·29	·31	·31
440	·38	·42	38	10	·38			·29	·32	·32
450	·38	·42	38	10	·38			·29	·32	·32
460	·39	·43	39	10	·39			·29	·32	·32
470	·39	·43	39	10	·39			·29	·32	·32
480	·40	·44	40	11	·40			·30	·33	·33
490	·40	·44	40	11	·40			·30	·33	·33
500	·41	·45	41	11	·41			·30	·33	·33

PLATED DECK REQUIRED

PLATED DECK REQUIRED

For Notes see page 113.

SHORT SUPERSTRUCTURES.

TABLE 21
(CONCLUDED.)

LENGTH L	SIDE PLATING.		WIDTH OF STRINGER AND TIE PLATES WITH WOOD DECK.		THICKNESS OF STRINGER AND TIE PLATES WITH WOOD DECK.			MINIMUM THICKNESS OF UNSHEATHED PLATED DECKS.		
	POOP	BRIDGE & FORECASTLE	STRINGER	TIE PLATE	POOP	BRIDGE	FORECASTLE	POOP	BRIDGE	FORECASTLE.
1	2	3	4	5	6	7	8	9	10	11
Feet.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
510	·41	·45	41	11	·41			·30	·33	·33
520	·42	·46	42	11	·42			·30	·34	·34
530	·42	·46	42	11	·42			·30	·34	·34
540	·43	·47	43	11	·43			·31	·34	·34
550	·43	·47	43	11	·43			·31	·34	·34
560	·44	·48	44	12	·44			·31	·35	·35
570	·44	·48	44	12	·44			·31	·35	·35
580	·45	·49	45	12	·45			·31	·35	·35
590	·45	·49	45	12	·45			·31	·35	·35
600	·46	·50	46	12	·46			·32	·36	·36
610	·46	·50	46	12	·46			·32	·36	·36
620	·47	·51	47	12	·47			·32	·36	·36
630	·47	·51	47	12	·47			·32	·36	·36
640	·48	·52	48	12	·48			·32	·37	·37
650	·48	·52	48	12	·48			·32	·37	·37

PLATED DECK REQUIRED

PLATED DECK REQUIRED

NOTES.—TABLE 21.

1. **Sheathed Decks.**—Where plated decks are sheathed with wood or approved composition the thickness given in Cols. 9, 10 and 11 may be reduced by 10 per cent.

2. **Allowance for Height of Platform.**—If the draught desired is not greater than ·7D (D being measured to the uppermost continuous deck) all thicknesses given in the Table may be reduced by 10 per cent.

THIS REDUCTION NOT TO BE APPLIED TO SHEERSTRAKE AT ENDS.
(L.O. LETTER 12/4/48)

3. **Stringer Angles.**—Angles connecting the deck to shell plating are to have the same thickness as required for plated decks, Cols. 9, 10 and 11.

IF BEAMS ON ALTERNATE FRAMES, DECK PLATING TO BE INCREASED IN ACCORDANCE WITH PREVIOUS PRACTICE.
(L.O. LETTER 12/4/48)

WHERE SHORT ERECTIONS, NOT EXTENDING COMPLETELY TO THE STERN OF A SHIP, ARE FITTED AT THE AFTER END, THE SCANTLINGS FOR FRAMES MAY BE TAKEN AS FOR A BRIDGE AND NOT A POOP, BUT THE SCANTLINGS FOR SIDE PLATING MAY BE TAKEN AS FOR A POOP.
(L.O. 26/1/51)

TABLE 22

END BULKHEADS OF SUPERSTRUCTURES.

Stiffeners spaced 30 inches apart.

BULKHEADS AT THE FORE END OF BRIDGES, OF UNPROTECTED POOPS THE LENGTH OF WHICH IS ·4L OR MORE AND OF ALL POOPS PROTECTING MACHINERY OPENINGS.

LENGTH L	BULB ANGLE STIFFENERS.	RIVETS IN END LUGS.		PLATING.
		Number.	Diameter.	
Feet	INCHES *Modulus—Inches*³		Inches.	Inches.
Under 160	$5\frac{1}{2} \times 3 \times \cdot34$ *5·60*	3	$\frac{5}{8}$	·30
160	$6 \times 3 \times \cdot35$ *6·95*	3	$\frac{5}{8}$	·30
200	$6 \times 3 \times \cdot45$ *8·35*	4	$\frac{5}{8}$	·30
240	$7 \times 3 \times \cdot37$ *10·10*	4	$\frac{5}{8}$	·33
280	$7 \times 3 \times \cdot48$ *12·05*	4	$\frac{3}{4}$	·36
320	$8 \times 3 \times \cdot40$ *14·30*	5	$\frac{3}{4}$	·39
360	$8 \times 3 \times \cdot49$ *16·35*	5	$\frac{3}{4}$	·42
400	$9 \times 3\frac{1}{2} \times \cdot41$ *19·15*	5	$\frac{3}{4}$	·44
440	$9 \times 3\frac{1}{2} \times \cdot51$ *21·90*	5	$\frac{3}{4}$	·44
480	$10 \times 3\frac{1}{2} \times \cdot42$ *24·80*	5	$\frac{3}{4}$	·44
520	$10 \times 3\frac{1}{2} \times \cdot53$ *28·45*	6	$\frac{3}{4}$	·44
560	$11 \times 3\frac{1}{2} \times \cdot45$ *31·95*	6	$\frac{3}{4}$	·44

BULKHEADS OF POOPS PARTIALLY PROTECTED OR LESS IN LENGTH THAN ·4L AND NOT PROTECTING MACHINERY OPENINGS.

LENGTH. L	ANGLE STIFFENERS.	RIVETS IN END LUGS.		PLATING.
		Number.	Diameter.	
Feet.	INCHES *Modulus—Inches*³		Inches.	Inches.
Under 150	$3 \times 2\frac{1}{2} \times \cdot30$ *1·00*	2	$\frac{5}{8}$	·24
150	$3\frac{1}{2} \times 2\frac{1}{2} \times \cdot32$ *1·40*	2	$\frac{5}{8}$	·24
200	$4 \times 3 \times \cdot34$ *1·90*	2	$\frac{5}{8}$	·26
250	$4 \times 3 \times \cdot46$ *2·50*	2	$\frac{5}{8}$	·29
300	$5 \times 3 \times \cdot38$ *3·15*	3	$\frac{5}{8}$	·32
350	$6 \times 3 \times \cdot35$ *4·20*	3	$\frac{5}{8}$	·35
400	$6 \times 3 \times \cdot44$ *5·20*	3	$\frac{3}{4}$	·38
450	$7 \times 3\frac{1}{2} \times \cdot40$ *6·35*	3	$\frac{3}{4}$	·38
500	$7 \times 3\frac{1}{2} \times \cdot48$ *7·55*	4	$\frac{3}{4}$	·38
550	$7 \times 3\frac{1}{2} \times \cdot50$ *7·80*	4	$\frac{3}{4}$	·38

BULKHEADS AT AFTER ENDS OF BRIDGES AND FORECASTLES.

LENGTH L	ANGLE STIFFENERS.	PLATING
Feet.	INCHES *Modulus—Inches*³	Inches.
Under 150	$2\frac{1}{2} \times 2\frac{1}{2} \times \cdot26$ *·60*	·20
150	$3 \times 2\frac{1}{2} \times \cdot28$ *·90*	·20
250	$3\frac{1}{2} \times 3 \times \cdot30$ *1·30*	·24
350	$4 \times 3 \times \cdot32$ *1·80*	·28
400 and above	$4 \times 3 \times \cdot40$ *2·20*	·30

Stiffeners to overlap, and be riveted to, boundary angles.

Section moduli above are given to nearest ·05.

NOTES.—TABLE 22.

1. **Correction for Spacing of Stiffeners.**—If the spacing of stiffeners differs from 30 inches, modulus of stiffeners is to be modified in direct proportion.

If the spacing of the stiffeners is greater than 30 inches, the thickness of plating is to be increased at the rate of ·01 inch for every 2 inches increase in spacing.

2. **Allowance for Height of Platform.**—When the draught d does not exceed ·7D, D being measured to the uppermost continuous deck, the scantlings given in the Table may be modified as follows :—

THICKNESS OF PLATING.

Where L = 200 feet or less, thickness may be 90 per cent of Table thickness.

Where L = 400 feet or above, thickness may be 85 per cent of Table thickness.

MODULUS OF STIFFENERS.

Where L = 200 feet or less, modulus may be 75 per cent of Table modulus.

Where L = 400 feet or above, modulus may be 70 per cent of Table modulus.

For intermediate lengths the percentage may be obtained by interpolation.

3. Bulkheads at the fore ends of Bridges which do not cover deck openings are to have plating as required by the Table, but the modulus of the stiffeners may be reduced by 10 per cent.

4. Particulars of sections and moduli are given in **Table 56.**

See Notice No 1948.

DECKHOUSES.

TABLE 23

(SEE CONTINUATION.)

FRONTS

OF LONG & SHORT DECKHOUSES.

Stiffeners spaced 30 inches apart.

LENGTH L	LOWER TIER. A		LOWER TIER. B		UPPER TIER. A		UPPER TIER. B	
	STIFFENERS	PLATING	STIFFENERS	PLATING	STIFFENERS	PLATING	STIFFENERS	PLATING
Feet.	Inches³ Modulus—Inches	Inches.	Inches³ Modulus—Inches	Inches.	Inches³ Modulus—Inches	Inches.	Inches³ Modulus—Inches	Inches.
200	BULB ANGLES 6 × 3 × ·32 *6·50*	·28	ANGLES 4 × 3 × ·41 *1·65*	·26	ANGLES $3\frac{1}{2}\times2\frac{1}{2}\times\cdot30$ *1·30*	·26	ANGLES 3 × $2\frac{1}{2}\times\cdot26$ *·85*	·26
300	7 × 3 × ·36 *9·95*	·34	5 × 3 × ·35 *2·95*	·28	4 × 3 × ·32 *1·80*	·26	3 × $2\frac{1}{2}\times\cdot30$ *1·00*	·26
400	8 × 3 × ·44 *15·20*	·38	5 × 3 × ·46 *3·80*	·30	5 × 3 × ·34 *2·85*	·28	$3\frac{1}{2}\times3\times\cdot32$ *1·40*	·28
500	9 × $3\frac{1}{2}\times\cdot52$ *22·20*	·40	6 × 3 × ·45 *5·30*	·32	6 × 3 × ·36 *4·30*	·30	4 × 3 × ·34 *1·90*	·30
600	10 × $3\frac{1}{2}\times\cdot58$ *30·10*	·42	6 × 3 × ·60 *6·95*	·34	6 × 3 × ·51 *5·95*	·32	4 × 3 × ·46 *2·50*	·32
	Stiffeners lugged at ends.						Stiffeners lugged when length L exceeds 500 feet.	

AFTER ENDS

OF LONG & SHORT DECKHOUSES.

Stiffeners spaced 36 inches apart.

LENGTH L	LOWER TIER. A		LOWER TIER. B		UPPER TIER. A		UPPER TIER. B	
	STIFFENERS	PLATING	STIFFENERS	PLATING	STIFFENERS	PLATING	STIFFENERS	PLATING
Feet.	Inches³ Modulus—Inches	Inches.	Inches³ Modulus—Inches	Inches.	Inches³ Modulus—Inches	Inches.	Inches³ Modulus—Inches	Inches.
200	ANGLES 3 × $2\frac{1}{2}\times\cdot28$ *·90*	·22	ANGLES $2\frac{1}{2}\times2\frac{1}{2}\times\cdot26$ *·60*	·22	ANGLES $2\frac{1}{2}\times2\frac{1}{2}\times\cdot26$ *·60*	·22	ANGLES $2\frac{1}{2}\times2\frac{1}{2}\times\cdot26$ *·60*	·22
300	$3\frac{1}{2}\times3\times\cdot30$ *1·30*	·26	3 × $2\frac{1}{2}\times\cdot26$ *·85*	·24	$2\frac{1}{2}\times2\frac{1}{2}\times\cdot28$ *·65*	·24	$2\frac{1}{2}\times2\frac{1}{2}\times\cdot26$ *·60*	·24
400	4 × 3 × ·30 *1·65*	·28	$3\frac{1}{2}\times3\times\cdot26$ *1·15*	·26	3 × $2\frac{1}{2}\times\cdot28$ *·90*	·24	3 × $2\frac{1}{2}\times\cdot26$ *·85*	·24
500	4 × 3 × ·30 *1·65*	·30	$3\frac{1}{2}\times3\times\cdot28$ *1·20*	·28	3 × $2\frac{1}{2}\times\cdot30$ *1·00*	·26	3 × $2\frac{1}{2}\times\cdot28$ *·90*	·26
600	4 × 3 × ·30 *1·65*	·30	$3\frac{1}{2}\times3\times\cdot30$ *1·30*	·30	$3\frac{1}{2}\times3\times\cdot30$ *1·00*	·26	3 × $2\frac{1}{2}\times\cdot30$ *1·00*	·26

Section moduli above are given to nearest ·05.

For Notes see page 117.

TABLE 23
(CONCLUDED.)

See notice No 1948.

DECKHOUSES.

SIDES
OF LONG & SHORT DECKHOUSES.

Stiffeners spaced 30 inches apart.

LENGTH L	LOWER TIER. A — STIFFENERS.	LOWER TIER. A — PLATING.	LOWER TIER. B — WHERE TWO TIERS ARE FITTED. STIFFENERS.	LOWER TIER. B — WHERE TWO TIERS ARE FITTED. PLATING.	LOWER TIER. B — WHERE ONE TIER ONLY IS FITTED. STIFFENERS.	LOWER TIER. B — WHERE ONE TIER ONLY IS FITTED. PLATING.	UPPER TIER. A — STIFFENERS.	UPPER TIER. A — PLATING.	UPPER TIER. B — STIFFENERS.	UPPER TIER. B — PLATING.
Feet.	∧ ANGLES ∨ Inches³ Modulus—Inches³	Inches.	∧ ANGLES ∨ Inches³ Modulus—Inches³	Inches.	∧ ANGLES ∨ Inches³ Modulus—Inches³	Inches.	∧ ANGLES ∨ Inches³ Modulus—Inches³	Inches.	∧ ANGLES ∨ Inches³ Modulus—Inches³	Inches.
200	$3\frac{1}{2}\times2\frac{1}{2}\times\cdot30$ *1·30*	·26	$3\frac{1}{2}\times2\frac{1}{2}\times\cdot28$ *1·20*	·26	$3\times2\frac{1}{2}\times\cdot28$ *·90*	·26	$3\times2\frac{1}{2}\times\cdot26$ *·85*	·26	$2\frac{1}{2}\times2\frac{1}{2}\times\cdot26$ *·60*	·24
300	$4\times3\times\cdot38$ *2·10*	·30	$3\frac{1}{2}\times2\frac{1}{2}\times\cdot30$ *1·30*	·27	$3\times2\frac{1}{2}\times\cdot30$ *1·00*	·26	$3\frac{1}{2}\times2\frac{1}{2}\times\cdot26$ *1·15*	·26	$3\times2\frac{1}{2}\times\cdot26$ *·85*	·24
400	$5\times3\times\cdot39$ *3·25*	·34	$4\times3\times\cdot30$ *1·65*	·28	$3\frac{1}{2}\times3\times\cdot30$ *1·30*	·27	$4\times3\times\cdot28$ *1·55*	·28	$3\times3\times\cdot30$ *1·00*	·25
500	$6\times3\times\cdot38$ *4·55*	·36	$4\times3\times\cdot40$ *2·20*	·29	$4\times3\times\cdot30$ *1·65*	·28	$4\times3\times\cdot38$ *2·10*	·30	$3\frac{1}{2}\times3\times\cdot30$ *1·30*	·26
600	$6\times3\times\cdot51$ *5·95*	·38	$5\times3\times\cdot34$ *2·85*	·30	$4\times3\times\cdot40$ *2·20*	·29	$5\times3\times\cdot36$ *3·00*	·32	$4\times3\times\cdot30$ *1·65*	·28

Stiffeners bracketed if two tiers fitted, and lugged if one tier only fitted.

Stiffeners lugged when length L exceeds 500 feet.

BEAMS
OF LONG & SHORT DECKHOUSES.

Spaced 30 inches apart.

LENGTH L	BEAMS WITH SUPERIMPOSED DECKHOUSE. SPAN. FEET. 15 — ANGLES	20 — BULB ANGLES	BEAMS WITHOUT SUPERIMPOSED DECKHOUSE. SPAN. FEET. 15 — ANGLES	20 — BULB ANGLES
Feet.	∧ ∨ Inches³ Modulus—Inches³	∧ ∨ Inches³ Modulus—Inches³	∧ ∨ Inches³ Modulus—Inches³	∧ ∨ Inches³ Modulus—Inches³
200	$4\times3\times\cdot36$ *2·00*	$5\times3\times\cdot42$ *3·50*	$4\times3\times\cdot32$ *1·80*	$5\times3\times\cdot36$ *3·00*
300	$5\times3\times\cdot30$ *2·55*	$6\times3\times\cdot34$ *4·10*	$4\times3\times\cdot39$ *2·15*	$5\times3\times\cdot44$ *3·65*
400	$5\times3\times\cdot39$ *3·25*	$5\times3\times\cdot40$ *5·15*	$5\times3\times\cdot30$ *2·55*	$6\times3\times\cdot33$ *4·00*
500	$5\times3\times\cdot44$ *3·65*	$5\times3\times\cdot45$ *5·65*	$5\times3\times\cdot36$ *3·00*	$5\times3\times\cdot33$ *4·50*
600	$6\times3\times\cdot36$ *4·30*	$6\times3\times\cdot30$ *6·25*	$5\times3\times\cdot41$ *3·40*	$5\times3\times\cdot41$ *5·25*

Section monuli above are given to nearest ·05.

DECK PLATING
ABOVE LONG DECKHOUSES.

LENGTH L	PERCENTAGE OF AREA OF STRENGTH DECK TO BE PROVIDED IN DECK ABOVE HOUSES. WHERE TWO DECKS ARE FITTED	WHERE THREE DECKS ARE FITTED	MINIMUM THICKNESS OF DECK PLATING UNSHEATHED	SHEATHED.
1	2	3	4	5
Feet.	Per Cent.	Per Cent.	Inches.	Inches.
200	70	—	·26	·24
300	60	—	·27	·25
400	50	55	·28	·26
500	40	50	·30	·27
600	—	45	·32	·28

For Notes see page 117.

TABLE 23

(98) THIS TABLE APPLIES ONLY TO TWO TIER DECKHOUSES, AND WHERE THERE IS A THIRD TIER THICKNESS MAY BE REDUCED.

DECKHOUSES

NOTES.—TABLE 23.

(5) WHERE LENGTH OF DECKHOUSE EXCEEDS ·3L THICKNESS OF SIDE PLATING AT ENDS TO BE INCREASED.

1. **Ends and Sides of Deckhouses.**—Col. A is to be used where the ratio of d/D is greater than ·85 in ships having a length of 200 feet and ·75 in ships of 400 feet and above, values for intermediate lengths are to be found by interpolation and D is to be measured to the deck on which the lower tier of houses is situated.

Col. B is to be used where the ratio d/D is less than ·70.

At intermediate draughts interpolation may be made between Cols. A and B.

If the spacing of the stiffeners differs from that given in the Table the modulus of the stiffeners is to be modified in direct proportion.

If the spacing of stiffeners is greater than that given in the Table the thickness of the plating is to be increased at the rate of ·01 inch for each 3 inches increase in spacing.

In deckhouses on Bridge Decks the modulus of the stiffeners at the front of the lower tier may be 70 cent of that given in the Table, Col. B.

2. **Beams.**—The scantlings of the beams given in the Table are those associated with a plated deck. If the beam spacing differs from 30 inches the modulus of the beams is to be modified in direct proportion.

(11) NO INCREASE IN AREA REQD. UNLESS BEAM SPACING EXCEEDS 36"

3. **Deck Plating Above Houses.**—Where the length of a deckhouse exceeds ·15L, deck plating of the sectional area derived from the Table is to be fitted at the top of the house.

(12) AREA IS GENERALLY THAT ABREAST OPENINGS.

The two and three decks referred to in Cols. 2 and 3 respectively, are the decks of the main hull as used in **Table 18.**

If there are two tiers of houses the sectional area of the top of each may be 80 per cent of the area derived from the Table, or alternatively the top of the upper tier may be 75 per cent, and of the lower tier 100 per cent of that area.

4. Where the height of deckhouses exceeds 9 feet the scantlings will be specially considered.

5. Particulars of sections and moduli are given in **Table 56.**

TABLE 24

BEAMS A

BREADTH B	BEAM SPACING.	CORRECTION FACTOR K		UNSUPPORTED SPAN. FEET. 6	8	10	12	14	16
Feet.	Inches			INCHES *Modulus—Inches*^{3}					
24	21	1·20	ANGLES	3 × 2½ × ·30 *1·00*	3 × 2½ × ·38 *1·25*	3½ × 3 × ·34 *1·45*	3½ × 3 × ·39 *1·70*		
28	22	1·20	ANGLES	3 × 2½ × ·34 *1·15*	3½ × 3 × ·32 *1·40*	3½ × 3 × ·37 *1·60*	3½ × 3 × ·44 *1·90*	4 × 3 × ·42 *2·30*	
32	23	1·20	ANGLES	3½ × 3 × ·32 *1·40*	3½ × 3 × ·38 *1·65*	3½ × 3 × ·44 *1·90*	4 × 3 × ·39 *2·15*	4 × 3 × ·48 *2·65*	5 × 3 × ·37 *3·10*
36	24	1·20	ANGLES	1·80	4 × 3 × ·38 *2·10*	4 × 3 × ·44 *2·40*	5 × 3 × ·32 *2·70* 3·05	5 × 3 × ·41 *3·40*	6 × 3 × ·33 *4·00*
40	25	1·20	ANGLES	2·45	5 × 3 × ·34 *2·85*	5 × 3 × ·39 *3·25*	5 × 3 × ·44 3·65 4·03	6 × 3 × ·37 *4·40*	5½ × 3 × ·32 5·40
44	26	1·20	ANGLES			6 × 3 × ·38 *4·55*	5 × 3 × ·39 *5·05*	5½ × 3 × ·36 *5·80*	6 × 3 × ·36 *7·10*
48	27	1·20	BULB ANGLES			5½ × 3 × ·38 *6·05*	6 × 3½ × ·34 *6·85*	6 × 3½ × ·41 *7·80*	6 × 3½ × ·48 *8·80*
52	28	1·20	BULB ANGLES			6 × 3½ × ·41 *7·80*	6 × 3½ × ·48 *8·80*	7 × 3½ × ·35 9·80	7 × 3½ × ·42 *10·95*
56	29	1·16	BULB ANGLES			9·80	7 × 3½ × ·41 *10·80*	7 × 3½ × ·47 *11·85*	*13·05*
60	30	1·12	BULB ANGLES		10·25	11·50	7 × 3½ × ·51 *12·65*	8 × 3½ × ·38 *13·85*	8 × 3½ × ·43 *15·05*
64	31	1·08	BULB ANGLES			13·40	8 × 3½ × ·41 *14·60*	8 × 3½ × ·46 *15·75*	8 × 3½ × ·52 *17·15*
68	32	1·04	BULB ANGLES			15·00	8 × 3½ × ·48 *16·20*	8 × 3½ × ·53 *17·40*	9 × 3½ × ·40 *18·90*
72	33	1·00	BULB ANGLES			16·00	8 × 3½ × ·53 *17·40*	9 × 3½ × ·40 *18·90*	9 × 3½ × ·46 *20·50*
76	34	1·00	BULB ANGLES				*18·20*	9 × 3½ × ·44 *19·90*	9 × 3½ × ·50 *21·60*
80	35	1·00	BULB ANGLES				9 × 3½ × ·41 *19·15*	9 × 3½ × ·47 *20·80*	9 × 3½ × ·54 *22·70*

Section moduli above are

NOTES.—TABLE 24.

1. **Application to Various Decks.**—(*a*) The modulus given in the Table applies to **Weather Deck Beams** in ships having a ratio of d/D not exceeding ·7 (D being measured to the uppermost continuous deck) with the exception of the following :—

(1) **Single Deck Ships** - - (*see* (*d*) *below*)
(2) **Short Bridges and Poops** - (*see* (*f*) *below*)
(3) **Forecastle Decks** - - (*see* (*g*) *below*)
(4) **The Forward ·12L of Weather Decks** (*see* (*g*) *below*)

(*b*) When d/D is ·85 or greater the modulus for Weather Deck Beams (except as qualified by (*d*) to (*g*) below) is to be the Table modulus multiplied by the factor K given in the third column.

D MEASURED TO RQDK FOR RQDK BEAMS. SEE SECT. 13.

(*c*) When d/D lies between ·7 and ·85 the correction factor is to be found by interpolation between 1·0 for d/D = ·7 and the Table factor K for d/D = ·85.

(*d*) For **Single Deck Ships** the modulus is to be obtained in accordance with the above Notes and increased by 20 per cent.

(*e*) For bridges forming an **Effective Superstructure** (**Section 2, clause 6**) the modulus is to be taken directly from the Table without the use of the factor K.

(*f*) For **Short Bridges and Poops** the modulus taken directly from the Table without the use of the factor K may be reduced by 30 per cent.

J.R.C. RULED THAT THIS MAY BE APPLIED TO POOP DK BEAMS IN TANKERS.

WEATHER DECKS.

TABLE 24

UNSUPPORTED SPAN. FEET. 18	20	22	24	26		CORRECTION FACTOR K	BEAM SPACING.	BREADTH B
<- INCHES *Modulus—Inches*^{3} ->							Inches.	Feet.
					ANGLES	1·20	21	24
					ANGLES	1·20	22	28
					ANGLES	1·20	23	32
6 × 3 × ·41 *4·90*	6·0	7·65			ANGLES	1·20	24	36
5½ × 3 × ·41 *6·40*	6 × 3 × ·40 *7·65*	9·65				1·20	25	40
6 × 3 × ·44 *8·20*	7 × 3 × ·35 *9·80*	7 × 3 × ·46 *11·65*				1·20	26	44
7 × 3½ × ·37 *10·15*	7 × 3½ × ·46 *11·65*	8 × 3½ × ·37 *13·65*	8 × 3½ × ·46 *15·75*			1·20	27	48
7 × 3½ × ·49 *12·25*	8 × 3½ × ·38 *13·85*	8 × 3½ × ·46 *15·75*	8 × 3½ × ·55 *17·85*	9 × 3½ × ·45 *20·20*		1·20	28	52
8 × 3½ × ·40 *14·35*	8 × 3½ × ·47 *16·00*	8 × 3½ × ·56 *18·05*	9 × 3½ × ·45 *20·20*	9 × 3½ × ·53 *22·45*	BULB ANGLES	1·16	29	56
8 × 3½ × ·49 *16·45*	8 × 3½ × ·56 *18·05*	9 × 3½ × ·45 *20·20*	9 × 3½ × ·54 *22·70*	10 × 3½ × ·44 *25·45*		1·12	30	60
9 × 3½ × ·39 *18·65*	9 × 3½ × ·45 *20·20*	9 × 3½ × ·54 *22·70*	10 × 3½ × ·43 *25·15*	10 × 3½ × ·52 *28·10*		1·08	31	64
9 × 3½ × ·46 20·50	9 × 3½ × ·53 *22·45*	10 × 3½ × ·42 *24·80*	10 × 3½ × ·51 *27·75*	*31·00*		1·04	32	68
9 × 3½ × ·52 *22·20*	10 × 3½ × ·41 *24·50*	10 × 3½ × ·49 *27·10*	10 × 3½ × ·58 *30·10*	11 × 3½ × ·48 *33·05*		1·00	33	72
9 × 3½ × ·57 *23·60*	10 × 3½ × ·45 *25·80*	10 × 3½ × ·53 *28·45*	11 × 3½ × ·44 *31·55*	11 × 3½ × ·52 *34·55*		1·00	34	76
10 × 3½ × ·41 *24·50*	10 × 3½ × ·48 *26·80*	10 × 3½ × ·57 *29·80*	11 × 3½ × ·47 *32·70*	11 × 3½ × ·55 *35·80*		1·00	35	80

given to nearest ·05.

NOTES.—TABLE 24 (*continued*).

(*g*) For the **Forward ·12L** of forecastles and weather decks, the Table modulus is to be multiplied by the factor K irrespective of the draught.

2. **Span** for use in the Table is to be measured in feet from girder to girder or from girder to a point midway between the toe of the bracket and the inner edge of the frame.

3. **Corrections to Modulus of Beams.**

FOR BEAM SPACING.

If the spacing at any point differs from that given in the Table the modulus is to be modified in direct proportion.

FOR HANGING CARGOES.

If the beams carry hanging cargo, such as chilled beef, the modulus is to be increased by 50 and 100 per cent for one or two tiers of quarters, respectively, but need not exceed the modulus of beams derived from **Table 25** and **Note 3** to that Table.

FOR BEAMS WITHOUT PLATING.

Where a plated deck is not fitted the modulus of the beam is to be increased by 30 per cent for use in **Table 56.**

4. For width of faying flanges *see* **Section 31, clause 1** (*b*).

5. Particulars of sections and moduli are given in **Table 56**

TABLE 25

BEAMS AT CARGO AN

BREADTH B	BEAM SPACING.	CORRECTION FACTOR C	UNSUPPORTED SPAN. FEET. 6	8	10	12	14	16
Feet.	Inches.		INCHES Modulus—Inches³					
24	21	·50	3 × 2½ × ·34 1·15	3½ × 3 × ·43 1·85	4 × 3 × ·48 2·65	5 × 3 × ·41 3·40		
28	22	·50	3 × 2½ × ·34 1·15	3½ × 3 × ·43 1·85		5 × 3 × ·45 3·75	6 × 3 × ·39 4·65	
32	23	·50	1·25	4 × 3 × ·36 2·00	5 × 3 × ·37 3·10	6 × 3 × ·35 4·20	5½ × 3 × ·30 5·15	5½ × 3 × ·40 6·25
36	24	·50	1·35	4 × 3 × ·40 2·20	5 × 3 × ·41 3·40	6 × 3 × ·39 4·65	5½ × 3 × ·38 6·05	6 × 3 × ·39 7·50
40	25	·50	1·45	4 × 3 × ·43 2·35	5 × 3 × ·44 3·65	5½ × 3 × ·31 5·30	5½ × 3 × ·46 6·95	6 × 3 × ·49 8·90
44	26	·55	1·6	5 × 3 × ·30 2·55	6 × 3 × ·34 4·10	5½ × 3 × ·37 5·95	6 × 3 × ·42 7·90	7 × 3 × ·38 10·25
48	27	·60	1·7	5 × 3½ × ·32 2·70	6 × 3½ × ·38 4·50	6 × 3½ × ·31 6·50	6 × 3½ × ·48 8·80	7 × 3½ × ·45 11·50
52	28	·65	1·8	5 × 3½ × ·34 2·85	6 × 3½ × ·42 4·95	6 × 3½ × ·37 7·25	7 × 3½ × ·36 9·95	7 × 3½ × ·52 12·80
56	29	·70			5·5	6 × 3½ × ·43 8·10	7 × 3½ × ·42 10·95	8 × 3½ × ·39 14·10
60	30	·75		3·15	6·2	6 × 3½ × ·50 9·05	7 × 3½ × ·49 12·25	8 × 3½ × ·44 15·25
64	31	·80			7·5	7 × 3½ × ·39 10·45	8 × 3½ × ·37 13·65	8 × 3½ × ·50 16·70
68	32	·85			9·05	7 × 3½ × ·48 12·05	8 × 3½ × ·43 15·05	8 × 3½ × ·56 18·05
72	33	·90			11·5	8 × 3½ × ·39 14·10	8 × 3½ × ·50 16·70	9 × 3½ × ·43 19·65
76	34	·90					9 × 3½ × ·39 18·65	9 × 3½ × ·48 21·05
80	35	·90					9 × 3½ × ·47 20·80	9 × 3½ × ·54 22·70

ANGLES

BULB ANGLES

Section moduli above are

BEAMS IN FRUIT CARRIERS 2/3 OF CARGO ½ (ALSO P & C)

& NOTATION "(TWO) LOWER DECKS FOR FRUIT CARGOES"

NOTES.—TABLE 25.

1. **Application to Various Decks.**—(*a*) For all **Cargo Decks** the modulus of the beams is to be determined directly from the Table and corrected as required below.

(*b*) For all **Accommodation Decks** the modulus derived from (*a*) is to be multiplied by the factor C given in the third column of the Table.

2. **Span** for use in the Table is to be measured from girder to girder or from girder to a point midway between the toe of the bracket and the inner edge of the frame.

3. **Corrections to Modulus of Beams.**

FOR BEAM SPACING.

If the spacing at any point differs from the spacing given in the Table, modulus is to be modified in direct proportion.

ACCOMMODATION DECKS. TABLE 25

UNSUPPORTED SPAN. FEET. 18	20	22	24	26		CORRECTION FACTOR C	BEAM SPACING.	BREADTH B
INCHES *Modulus—Inches*³							Inches.	Feet.
					ANGLES	·50	21	24
					ANGLES	·50	22	28
					ANGLES	·50	23	32
6 × 3 × ·51 *9·15*					BULB ANGLES	·50	24	36
7 × 3 × ·43 *11·15*	7 × 3 × ·56 *13·50*				BULB ANGLES	·50	25	40
7 × 3 × ·53 *13·00*	8 × 3 × ·47 *15·90*	9 × 3½ × ·40 *18·90*			BULB ANGLES	·55	26	44
8 × 3½ × ·41 *14·60*	8 × 3½ × ·55 *17·85*	9 × 3½ × ·49 *21·35*	10 × 3½ × ·43 *25·15*		BULB ANGLES	·60	27	48
8 × 3½ × ·48 *16·20*	9 × 3½ × ·42 *19·40*	9 × 3½ × ·55 *23·00*	10 × 3½ × ·47 *26·45*	10 × 3½ × ·59 *30·45*	BULB ANGLES	·65	28	52
8 × 3½ × ·54 *17·60*	9 × 3½ × ·47 *20·80*	10 × 3½ × ·40 *24·20*	10 × 3½ × ·52 *28·10*	11 × 3½ × ·45 *31·95*	BULB ANGLES	·70	29	56
9 × 3½ × ·39 *18·65*	9 × 3½ × ·51 *21·90*	10 × 3½ × ·44 *25·45*	10 × 3½ × ·55 *29·15*	11 × 3½ × ·48 *33·05*	BULB ANGLES	·75	30	60
9 × 3½ × ·44 *19·90*	9 × 3½ × ·56 *23·30*	10 × 3½ × ·48 *26·80*	10 × 3½ × ·59 *30·45*	11 × 3½ × ·52 *34·55*	BULB ANGLES	·80	31	64
9 × 3½ × ·48 *21·05*	10 × 3½ × ·40 *24·20*	10 × 3½ × ·51 *27·75*	11 × 3½ × ·44 *31·55*	11 × 3½ × ·55 *35·80*	BULB ANGLES	·85	32	68
9 × 3½ × ·53 *22·45*	10 × 3½ × ·44 *25·45*	10 × 3½ × ·55 *29·15*	11 × 3½ × ·47 *32·70*	11 × 3½ × ·58 *37·00*	BULB ANGLES	·90	33	72
9 × 3½ × ·57 *23·60*	10 × 3½ × ·47 *26·45*	10 × 3½ × ·58 *30·10*	11 × 3½ × ·50 *33·80*	11 × 3½ × ·61 *38·20*	BULB ANGLES	·90	34	76
10 × 3½ × ·42 *24·80*	10 × 3½ × ·51 *27·75*	*31·15*	11 × 3½ × ·53 *35·00*	11 × 3½ × ·63 *39·00*	BULB ANGLES	·90	35	80

given to nearest ·05.

NOTES.—TABLE 25 (*continued*).

For 'Tween Deck Height.

If the 'tween deck height in cargo spaces differs from 8 feet 6 inches, modulus is to be modified in direct proportion.

For Hanging Cargoes.

If the beams carry hanging cargo, such as chilled beef, and may be simultaneously loaded above with cargo, modulus is to be increased by 30, 60 and 90 per cent for one, two and three tiers respectively. For accommodation decks these percentages are to be 50, 100 and 150 respectively.

For Beams Without Plating.

Where a plated deck is not fitted, the modulus of the beam is to be increased by 30 per cent for use in **Table 56.**

4. For width of faying flanges *see* **Section 31, clause 1** (*b*).

5. Particulars of sections and moduli are given in **Table 56.**

TABLE 26 LONGITUDINALS AT WEATHER DECKS.

LENGTH L	SPACING OF LONGITUDINALS.	CORRECTION FACTOR K	UNSUPPORTED SPAN. FEET. 6	8	10	12	
Feet.	Inches.		INCHES³ Modulus—Inches				
240	28½	1·20	5 × 3 × ·41 *3·40*	5 × 3 × ·48 *3·95*			ANGLES
260	29	1·20	5 × 3 × ·44 *3·65*	6 × 3 × ·35 *4·20*			ANGLES
280	29½	1·20	5 × 3 × ·46 *3·80*	6 × 3 × ·37 *4·40*	6 × 3 × ·42 *5·00*		ANGLES
300	30	1·20	5 × 3 × ·48 *3·95*	6 × 3 × ·39 *4·65*	5 × 3 × ·41 *5·25*	5½ × 3 × ·37 *5·95*	ANGLES
320	30½	1·20	6 × 3 × ·35 *4·20*	5½ × 3 × ·30 *5·15*	5½ × 3 × ·38 *6·05*	6 × 3 × ·35 *6·95*	BULB ANGLES
340	31	1·20	6 × 3 × ·37 *4·40*	5½ × 3 × ·34 *5·60*	6 × 3 × ·34 *6·80*	6 × 3 × ·43 *8·05*	BULB ANGLES
360	31½	1·20	6 × 3½ × ·39 *4·65*	6 × 3½ × ·28 *6·10*	6 × 3½ × ·40 *7·65*	6 × 3½ × ·50 *9·05*	BULB ANGLES
380	32	1·18	6 × 3½ × ·41 *4·85*	6 × 3½ × ·32 *6·60*	6 × 3½ × ·45 *8·35*	7 × 3½ × ·38 *10·25*	BULB ANGLES
400	32½	1·16	6 × 3½ × ·43 *5·05*	6 × 3½ × ·36 *7·10*	*9·20*	7 × 3½ × ·44 *11·30*	BULB ANGLES
420	33	1·14		6 × 3½ × ·40 *7·65*	7 × 3½ × ·36 *9·95*	7 × 3½ × ·50 *12·45*	BULB ANGLES
440	33½	1·12		6 × 3½ × ·44 *8·20*	7 × 3½ × ·41 *10·80*	8 × 3½ × ·36 *13·45*	BULB ANGLES
460	34	1·10		6 × 3½ × ·47 *8·65*	7 × 3½ × ·46 *11·65*	8 × 3½ × ·41 *14·60*	BULB ANGLES
480	34½	1·08		*9·20*	7 × 3½ × ·50 *12·45*	8 × 3½ × ·46 *15·75*	BULB ANGLES
500	35	1·06		7 × 3½ × ·43 *9·65*	*13·00*	8 × 3½ × ·50 *16·70*	BULB ANGLES

Section moduli above are given to nearest ·05.

NOTES.—TABLE 26.

1. **Application to Various Decks.**—(*a*). The modulus given in the Table applies to **Weather Deck** longitudinals, outside the line of deck openings, in ships having a ratio of d/D not exceeding ·7 (D being measured to the uppermost continuous deck) with the exception of the following:—

(1) **Single Deck Ships** ... ... (*see* (*d*) below)

(2) **Short Bridges** ... ... (*see* (*f*) below)

(*b*) When d/D is ·85 or greater the modulus for Weather Deck longitudinals (except as qualified by (*d*) to (*h*) below) is to be the Table modulus multiplied by the factor K given in the third column.

(*c*) When d/D lies between ·7 and ·85 the correction factor is to be found by interpolation between 1·0 for d/D=·7 and the Table factor K for d/D=·85.

(*d*) For **Single Deck** Ships the modulus is to be obtained in accordance with the above Notes and increased by 20 per cent.

(*e*) For bridges forming an **Effective Superstructure** (**Section 2, clause 6**) the modulus is to be taken directly from the Table without the use of the factor K.

(*f*) For **Short Bridges** the modulus taken directly from the Table without the use of the factor K may be reduced by 30 per cent.

(*g*) Outside the line of openings the modulus derived as above is to be maintained for ·4L amidships and may be gradually reduced to 85 per cent and 70 per cent of its midship value at ·1L from the forward and after ends respectively.

(*h*) Within the line of openings the modulus may be 85 per cent and 70 per cent of that required outside the line of openings amidships for the forward ·12L and the remainder of the length respectively.

2. **Span** for use in the Table is to be measured from transverse to transverse or from transverse to a point midway between the toe of the end bracket and the bulkhead.

3. **Corrections to Modulus of Longitudinals.**

For Spacing of Longitudinals.

If the spacing at any point differs from the spacing given in the Table, modulus is to be modified in direct proportion.

For Hanging Cargoes.

If the longitudinals carry hanging cargo, such as chilled beef, the modulus is to be increased by 50 and 100 per cent for one or two tiers of quarters, respectively, but need not exceed the modulus of longitudinals derived from **Table 27** and **Note 3** to that Table.

4. For width of faying flanges *see* **Section 31, clause 1** (*b*).

5. Particulars of sections and moduli are given in **Table 56.**

TABLE 27

LONGITUDINALS AT CARGO AND ACCOMMODATION DECKS.

LENGTH L	SPACING OF LONGITUDINALS.	CORRECTION FACTOR C	UNSUPPORTED SPAN. FEET. 6	8	10	12	
Feet.	Inches.		INCHES *Modulus—Inches*³				
240	$28\frac{1}{2}$	·50	4 × 3 × ·36 *2·00*	5 × 3 × ·36 *3·00*			ANGLES
260	29	·50	4 × 3 × ·42 *2·30*	5 × 3 × ·40 *3·30*			
280	$29\frac{1}{2}$	·50	5 × 3 × ·32 *2·70*	5 × 3 × ·45 *3·75*	6 × 3 × ·38 *4·55*		
300	30	·55	5 × 3 × ·36 *3·00*	5 × 3 × ·48 *3·95*	6 × 3 × ·41 *4·85*	$5\frac{1}{2}$× 3 ×·37 *5·95*	ANGLES
320	$30\frac{1}{2}$	·60	5 × 3 × ·40 *3·30*	6 × 3 × ·36 *4·30*	5 × 3 × ·42 *5·35*	$5\frac{1}{2}$× 3 ×·41 *6·40*	
340	31	·62	5 × 3 × ·44 *3·65*	6 × 3 × ·40 *4·75*	$5\frac{1}{2}$×3 × ·36 *5·80*	6 × 3 × ·35 *6·95*	
360	$31\frac{1}{2}$	·65	6 × 3 × ·34 *4·10*	5 × 3 × ·40 *5·15*	$5\frac{1}{2}$×3 × ·40 *6·25*	6 × 3 × ·38 *7·35*	
380	32	·67	6 × 3 × ·37 *4·40*	$5\frac{1}{2}$×3 × ·34 *5·60*	$5\frac{1}{2}$×3 × ·44 *6·70*	6 × 3 × ·42 *7·90*	
400	$32\frac{1}{2}$	·70	6 × $3\frac{1}{2}$×·40 *4·70*	*5·95*	6 × $3\frac{1}{2}$×·36 *7·10*	6 × $3\frac{1}{2}$×·45 *8·35*	BULB ANGLES
420	33	·72		6 × $3\frac{1}{2}$×·30 *6·35*	6 × $3\frac{1}{2}$×·40 *7·65*	6 × $3\frac{1}{2}$×·49 *8·95*	
440	$33\frac{1}{2}$	·75		6 × $3\frac{1}{2}$×·34 *6·85*	6 × $3\frac{1}{2}$×·43 *8·10*	*9·40*	
460	34	·77		6 × $3\frac{1}{2}$×·37 *7·25*	6 × $3\frac{1}{2}$×·46 *8·50*	7 × $3\frac{1}{2}$×·36 *9·95*	
480	$34\frac{1}{2}$	·80		6 × $3\frac{1}{2}$×·40 *7·65*	6 × $3\frac{1}{2}$×·50 *9·05*	7 × $3\frac{1}{2}$×·39 *10·45*	
500	35	·82		6 × $3\frac{1}{2}$×·42 *7·95*	*9·45*	7 × $3\frac{1}{2}$×·42 *10·95*	

Section moduli above are given to nearest ·05.

NOTES.—TABLE 27.

1. **Application to Various Decks.**—(*a*) For all **Cargo Decks** the modulus of the deck longitudinals is to be determined directly from the Table and corrected as required below.

(*b*) For all **Accommodation Decks** the modulus derived from (*a*) is to be multiplied by the factor C given in the third column of the Table.

2. **Span** for use in the Table is to be measured from transverse to transverse or from transverse to a point midway between the toe of the end bracket and the bulkhead.

3. **Corrections to Modulus of Longitudinals.**

For Spacing of Longitudinals.

If the spacing at any point differs from the spacing given in the Table modulus is to be modified in direct proportion.

For 'Tween Deck Height.

If the 'tween deck height in cargo spaces differs from 8 feet 6 inches modulus is to be modified in direct proportion.

For Hanging Cargoes.

If the longitudinals carry hanging cargo, such as chilled beef, and may be simultaneously loaded above with cargo, the modulus is to be increased by 30, 60 and 90 per cent for one, two and three tiers respectively. For accommodation decks these percentages are to be 50, 100 and 150 respectively.

4. For width of faying flanges *see* **Section 31, clause 1** (*b*).

5. Particulars of sections and moduli are given in **Table 56.**

314 †

4 (9) Spacing of transverses should not exceed 12 ft.

See Notice N° 1948

TABLE 28

BEAM KNEES AND END BRACKETS OF DECK LONGITUDINALS.

DEPTH OF BEAM, FRAME, OR LONGITUDINAL. I/y	KNEES OR BRACKETS.					RIVETS.		
	DEPTH FROM DECK.	OVERLAP ON BEAM OR LONGITUDINAL.	NOT FLANGED.	FLANGED.		NUMBER.		DIAMETER.
			THICKNESS.	THICKNESS.	WIDTH.	BEAM KNEE.	LONGITUDINAL BRACKET.	
1	2	3	4	5	6	7	8	9
Inches.	Inches.	Inches.	Inches.	Inches.	Inches.			Inches.
5 and below. UP TO 5·35	12½	9	·28			4	6	⅝
5½ 5·15 to 6·95	14	10	·29			4	5	¾
6 6·10 to 9·15	15	11	·30			4	6	¾
7 9·80 to 13·50	17½	13	·33			4	7	¾
8 13·45 to 18·05	20	14½	·36			5	8	¾
9 18·65 to 23·60	22½	16	·39			5	8	⅞
10 24·20 to 30·45	25	18	·42	·36	2	6	9	⅞
11 31·55 to 39·0	27½	20	·45	·38	2¼	7		⅞
12	30	22	·48	·40	2½	8		⅞
13½	34	24½	·50	·42	2¾	9		⅞
15	38	27	·52	·44	3	10		⅞

MIN^M DEPTH FOR SINGLE DECK

For Notes see page 125.

(74) FRAME BRACKETS WHERE DECK FRAMED LONGITUDINALLY FROM TABLE 28.

(40) BEAM OF O.A. SECTION MAY BE CONVERTED TO B.A. FOR USE IN TABLES.

See NOTICE 1948.
Beam knees used as frame straps: 1951 Rules page 121.

TABLE 28

(13) BEAM KNEE MAY BE GOVERNED BY SPAN OF THE BEAM ADJACENT TO SHIP'S SIDE IN CERTAIN CASES.

NOTES.—TABLE 28.

1. **Beam Knees.**—The dimensions shown in Cols. 2 to 6 apply to Beam Knees and, with the exceptions mentioned in Notes 2 and 3, are based on the depth of the beams.

2. In single deck ships the depth of the beam knees is to be governed by the depth of the hold frame or beam, whichever is the greater, with a minimum depth of knee of 14 inches, and these knees are to be maintained throughout. At the second deck of two deck ships where the hold frames terminate at the second deck, the depth of the beam knees is to be similarly determined.

i.e. MIN KNEE TAKEN AS 16"×10"×.29 4-¾"R.

3. If the beam knees act as a strap connection between 'tween deck and hold frames, the overlaps of the beam and hold frame on the knee are to be as required by Col. 3. The overlap of the 'tween deck frame on the knee is to be twice the depth of the 'tween deck frame. The knees are to be flanged 3 inches, or if already required by the Table to be flanged, the thickness is to be increased by ·08 inch. The number of rivets in the overlap of the 'tween deck frame is to be three if the depth of frame does not exceed 5 inches, four if not exceeding 6 inches and five where not exceeding 8 inches. The number of rivets to the beam is to be as required by Col. 7 and the number in the hold frame is to be two greater.

(88) FOR TWEEN DECK FRAME WELDED TO HOLD FRAME, THE REQUIREMENTS FOR FLANGING AND EXTRA THICKNESS NEED NOT BE APPLIED.

4. In the Panting region the depth of the knees at the lowest deck is to be governed by the depth of the hold frame or beam, whichever is the greater.

5. **Brackets to Deck Longitudinals.**—Brackets to Deck Longitudinals are to have dimensions not less than those given in Cols. 2 and 3, but suitable for the number of rivets given in Col. 8.

$N = \frac{L \cdot D_M}{100} = \frac{L}{2} \times \frac{L \cdot D_M}{50}$ but $\frac{L \cdot D_M}{50} = W$ at 50 ft / tons.

$= \frac{WL}{2}$ which is half the BM for a concentrated load W supported over a span L.

$N = \frac{BM}{2}$ STRESS $= \frac{2N}{1/5}$.

TABLE 29

DECK GIRDERS.

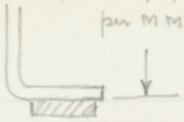
(SEE CONTINUATION.)

BM =

NUMERAL. ×2	DEPTH OF END BRACKETS BELOW DECK.	DEPTH OF WEB PLATE BELOW DECK AND MINIMUM THICKNESS.							
		Inches 10 × ·32	Inches 11 × ·34	Inches 12 × ·34	Inches 13 × ·34	Inches 14 × ·34	Inches 15 × ·36	Inches 16 × ·36	Inches 17 × ·36
		REDUCTION IN FACE AREA (SQUARE INCH) PER ·1 INCH INCREASE IN WEB THICKNESS (see also NOTE 4).							
		·30	·30	·35	·40	·40	·45	·45	·50
		FACE AREA.							
	Inches.	Square Inches.	Square Inches	Square Inches.	Square Inches.	Square Inches	Square Inches.	Square Inches.	Square Inches.
50	19	~~2·6~~ ~~·8~~ STRESS 6·9 14·5							
100	21	2·6 ~~4·5~~ 6·7 30	2·1 ~~3·7~~ 6·75 32	1·7 ~~3·2~~ 6·25 32					
200	24	5·2 ~~6·2~~ 7·7 52	4·5 ~~5·4~~ 7·35 54·5	3·9 ~~4·7~~ 7·15 56	3·3 ~~4·1~~ 7·15 56	2·8 ~~3·6~~ 7·3 55			
300	27	7·1 8·85 68	6·2 8·5 70·5	5·5 8·35 72	4·8 8·1 74	4·2 8·1 74	3·6	3·2	2·7
400	30	9·9 8·7 92	8·7 8·5 94	7·8 8·35 96	6·9 8·2 98	6·1 8·2 98	5·4	4·8	4·3
600	33		13·8 8·4 143	12·4 8·45 142	11·1 8·3 145	10·0 8·1 148	9·0	8·2	7·4
800	36			17·0	15·4	14·0	12·6	11·6	10·6
1000	38			21·7	19·7	17·9	16·3	15·0	13·8
1200	40				23·9	21·8	20·0	18·5	17·0
1400	42						23·7	22·0	20·2
1600	44							25·5	23·4
1800	46								26·6
2000	48								
2200									
2400									
2600									

For Notes see page 129.

(82) IF NUMERAL EXCEEDS 2000, DEPTH OF BRACKET TO REMAIN AT 48", BUT RIVETING TO BE INCREASED.



DECK GIRDERS.

TABLE 29

(SEE CONTINUATION.)

DEPTH OF WEB PLATE BELOW DECK AND MINIMUM THICKNESS.								DEPTH OF END BRACKETS BELOW DECK.	NUMERAL.
Inches 18 × ·36	Inches 19 × ·38	Inches 20 × ·38	Inches 21 × ·38	Inches 22 × ·38	Inches 23 × ·40	Inches 24 × ·40	Inches 25 × ·40		
REDUCTION IN FACE AREA (SQUARE INCH) PER ·1 INCH INCREASE IN WEB THICKNESS (see also NOTE 4).									
·50	·55	·60	·60	·65	·65	·70	·70		
FACE AREA.									
Square Inches.	Square Inches.	Square Inches.	Square Inches.	Square Inches.	Square Inches.	Square Inches.	Square Inches.	Inches.	
								19	50
								21	100
								24	200
2·3								27	300
3·8	3·3	2·8	2·5					30	400
6·8	6·0	5·4	5·0	4·5	3·9	3·5	3·1	33	600
9·8	8·9	8·1	7·5	6·9	6·2	5·7	5·2	36	800
12·8	11·7	10·8	10·1	9·3	8·6	7·9	7·4	38	1000
15·8	14·6	13·5	12·6	11·8	10·9	10·1	9·5	40	1200
18·8	17·4	16·2	15·2	14·2	13·2	12·3	11·6	42	1400
21·9	20·3	19·0	17·7	16·7	15·5	14·6	13·8	44	1600
24·9	23·2	21·7	20·3	19·1	17·9	16·8	15·9	46	1800
27·9	26·1	24·4	22·9	21·5	20·3	19·1	18·1	48	2000
		27·1	25·5	23·9	22·6	21·3	20·2		2200
				26·3	24·9	23·6	22·3		2400
							24·4		2600

For Notes see page 129.

TABLE 29
(CONCLUDED.)

DECK GIRDERS.

NUMERAL.	DEPTH OF END BRACKETS BELOW DECK.	DEPTH OF WEB PLATE BELOW DECK AND MINIMUM THICKNESS.										
		Inches 26×·40	Inches 27×·42	Inches 28×·42	Inches 29×·42	Inches 30×·42	Inches 31×·44	Inches 32×·44	Inches 33×·44	Inches 34×·44	Inches 35×·46	Inches 36×·46
		REDUCTION IN FACE AREA (SQUARE INCH) PER ·1 INCH INCREASE IN WEB THICKNESS (see also NOTE 4).										
		·75	*·80*	*·80*	*·85*	*·85*	*·90*	*·90*	*·95*	*·95*	*1·00*	*1·00*
		FACE AREA.										
	Inches.	Sq. Ins.	Sq. Ins.	Sq. Ins.	Sq. Ins.	Sq. Ins.	Sq. Ins.	Sq. Ins.	Sq. Ins.	Sq. Ins.	Sq. Ins.	Sq. Ins.
50	19											
100	21											
200	24											
300	27											
400	30											
600	33											
800	36	4·7	4·2	3·8	3·3							
1000	38	6·8	6·1	5·6	5·2	4·7	4·1	3·7	3·3			
1200	40	8·9	8·1	7·6	7·0	6·5	5·8	5·4	4·9	4·5	3·9	3·4
1400	42	10·9	10·1	9·5	8·8	8·3	7·5	7·1	6·5	6·0	5·4	4·9
1600	44	13·0	12·1	11·4	10·6	10·1	9·3	8·7	8·1	7·6	6·9	6·4
1800	46	15·0	14·0	13·3	12·5	11·8	11·0	10·4	9·8	9·2	8·4	7·9
2000	48	17·1	16·0	15·2	14·3	13·6	12·7	12·0	11·4	10·7	9·9	9·3
2200		19·2	18·0	17·1	16·2	15·4	14·4	13·7	13·0	12·3	11·5	10·8
2400		21·2	20·0	19·0	18·0	17·2	16·1	15·4	14·6	13·9	13·0	12·3
2600		23·3	22·0	20·9	19·9	18·9	17·9	17·0	16·2	15·4	14·6	13·8
2800			24·0	22·9	21·8	20·7	19·6	18·7	17·8	17·0	16·1	15·2
3000				24·8	23·6	22·5	21·3	20·4	19·5	18·6	17·7	16·7

For Notes see page 129.

TABLE 29

MAXIMUM DEFLECTION PERMITTED IS $\ell/1500$ (PER J.M.M. 30/11/49)

NOTES.—TABLE 29.

1. Longitudinal Girders.

The Numeral for use in the Table is given by :

$$\frac{l^2 \times b \times h}{100}$$

where l = the span of the girder, in feet, from pillar to pillar, or from pillar to bulkhead less half the distance between the toe of the end bracket and the bulkhead.

b = the mean width of deck, in feet, supported by the girder.

h is to be measured as follows :

(*a*) For decks on which cargo is carried h is the mean height in feet from top of beam to top of beam of the 'tween decks next above the girder.

(*b*) For decks under accommodation spaces h is 4 feet. (*See also* Note 1 (*e*).)

(*c*) For weather decks, except in the forward ·12L, h is 4 feet if the draught does not exceed ·7D and 5 feet if the draught is ·85D or greater, with intermediate values in proportion, D being measured to the uppermost continuous deck. (*See also* Note 1 (*e*).)

(3) INCLUDES FOCSLES ON C.S.S. SHIPS.

(*d*) For the forward ·12L of weather decks, h is to be 5 feet irrespective of draught.

(*e*) For decks above the uppermost continuous deck h, as given in (*b*) and (*c*), may be successively reduced by one foot for each deck to a minimum of 1·5 feet.

(*f*) Where decks support a hanging cargo, such as chilled meat, in addition to deck loads, the value of h is to be increased by 2·5 feet for one tier, 5 feet for two tiers and 7·5 feet for three tiers of quarters.

2. Strong Hatch Side Coamings and End Beams in 'Tween Decks.

(*a*) SIDE COAMINGS.

The Numeral for use in the Table is given by :

$$\text{H}\quad \frac{1{\cdot}1 \times l^2 \times b \times h}{100}$$

where l = the length of the hatchway in feet.

b = the mean breadth in feet of deck, including hatchway, supported by the coaming.

h = the mean height in feet of 'tween decks as in Note 1.

H THE EXTRA 10% APPLIES TO TWEEN DECK HATCH SIDE COAMINGS WITHOUT QUALIFICATION AS TO THE WAY IN WHICH THEY ARE SUPPORTED. (J.M.M. 23/1/50)

NOT TO BE APPLIED TO PASSENGER DECKS. (J.R.C. 15/6/50)

(*b*) HATCH END BEAMS.

For strong hatch end beams which are supported at the centre line and carry the hatch side coamings only, the Numeral for use in the Table is given by :

$$\cdot 75\ B \times \frac{l \times b \times h}{100}$$

where B = the span of the hatch end beam, in feet, measured from the centre line to the ship's side less half the distance between the toe of the bracket and the ship's side.

l, b and h are measured as in Note 2 (*a*).

Where the hatch end beam supports the hatch side coaming and, in addition, an adjacent longitudinal girder in line, the Numeral is given by :

$$\cdot 75\ B \left(\frac{l_1 \times b_1 \times h}{100} + \frac{l_2 \times b_2 \times h}{100} \right)$$

where l_1, b_1 and h are measured as in Note 2 (*a*) and l_2 and b_2 are measured as in Note 1.

(*c*) The depth of strong hatch end beams derived from the Table is to be maintained for the full breadth of the ship.

(*d*) Strong hatch side coamings and end beams supporting deck longitudinals in association with transverses will be specially considered.

3. Transverses Supporting Deck Longitudinals. (9) SPACING OF TRANSVERSES SHOULD NOT EXCEED 12 FT.

The Numeral for use in the Table is given by :

$$\frac{l^2 \times b \times h}{100}$$

where l = the span, in feet, of the transverse measured from pillar to pillar or from pillar to ship's side less half the distance between the toe of the bracket and the ship's side.

b is the length of deck in feet supported by the transverses.

h is measured as in Note 1.

In single deck ships the depth of the transverses is to be increased by 15 per cent.

4. The sectional area of girder flanges derived from the Table may take the form of rolled sections, or flanged girder plates, with rider plates where necessary, the depth of the girder being measured to the bottom of the web. Where the depth of beam or longitudinal notches exceeds 50 per cent of the depth of the girder or 12 inches, whichever is less, the face area is to be suitably increased. The width of the flange is not to exceed the depth of the girder. (10) RIDER PLATE ASSUMED TO BE BELOW THE FLANGE.

5. For end connections and constructional details *see* **Section 15, clauses 3 to 6.**

TABLE 30

DECK RUNNERS.

NUMERAL.	DOUBLE ANGLES.		SINGLE ANGLE OR BULB ANGLE.
	Inches		Inches
5	3 × 2½ × ·26 ⅓ = 2 × ·57 = 1·14	ANGLES	3½ × 3 × ·36 ⅓ = 1·04
10	3½ × 3 × ·30 ·88 = 1·76		5 × 3 × ·31 1·83
15	4 × 3 × ·32 1·21 = 2·42		5 × 3 × ·44 2·53
20	4 × 3 × ·40 1·50 = 3·00	BULB ANGLES	5 × 3 × ·32
25	4 × 3 × ·45 1·69 = 3·38		5 × 3 × ·40
30	5 × 3 × ·36 2·10 = 4·20		5½ × 3 × ·34
35	5 × 3 × ·40 2·31 = 4·62		6 × 3 × ·32
40	5 × 3 × ·46		6 × 3 × ·38
45	6 × 3 × ·36		6 × 3 × ·48
50	6 × 3 × ·40		7 × 3 × ·36
55	6 × 3 × ·44		7 × 3 × ·40

NOTES.—TABLE 30.

1. The Numeral is to be determined in accordance with **Table 29, Note 1.**
2. The runners are to be fitted with the deep flange vertical.

TABLE 31

(SEE CONTINUATION.)

PILLARS.

NUMERAL.	LENGTH AND FORM OF PILLAR.											
	Feet 8						Feet 12					
	TUBULAR.	DOUBLE CHANNELS AND FACE PLATES.		SOLID.			TUBULAR.	DOUBLE CHANNELS AND FACE PLATES.		SOLID.		
	OUTSIDE DIAMETER.	CHANNELS.	FACE PLATES.	DIAMETER.	RIVETS IN ENDS.		OUTSIDE DIAMETER.	CHANNELS.	FACE PLATES.	DIAMETER.	RIVETS IN ENDS.	
	Inches.	Inches.	Inches.	Inches.	No.	Inches.	Inches.	Inches.	Inches.	Inches.	No.	Inches.
4	3 × ·30			$2\frac{3}{8}$	2	$\frac{7}{8}$	$3\frac{1}{2}$ × ·34			$2\frac{7}{8}$	2	$\frac{7}{8}$
6	$3\frac{1}{2}$ × ·34			$2\frac{5}{8}$	2	$\frac{7}{8}$	4 × ·36			$3\frac{1}{8}$	2	$\frac{7}{8}$
8	4 × ·36			$2\frac{7}{8}$	2	$\frac{7}{8}$	5 × ·36			$3\frac{3}{8}$	2	$\frac{7}{8}$
10	5 × ·36 A = 5·25	6 × 3 × 3 × ·36 2 × 4·31		$3\frac{1}{8}$	2	$\frac{7}{8}$	6 × ·38 A = 6·65	6 × 3 × 3 × ·44 2 at 4·79		$3\frac{5}{8}$	3	$\frac{7}{8}$
15	6 × ·40 A = 7·60	6 × $3\frac{1}{2}$ × $3\frac{1}{2}$ × ·36 5·33		$3\frac{1}{2}$	3	$\frac{7}{8}$	7 × ·38 A = 8·00	7 × $3\frac{1}{2}$ × $3\frac{1}{2}$ × ·36 5·80		$4\frac{1}{4}$	3	$\frac{7}{8}$
20	7 × ·40 A = 8·30	7 × $3\frac{1}{2}$ × $3\frac{1}{2}$ × ·38 5·94		4	3	1	8 × ·40 A = 9·5	8 × $3\frac{1}{2}$ × $3\frac{1}{2}$ × ·38 6·42		5	4	1
30	8 × ·40 A = 9·5	8 × $3\frac{1}{2}$ × $3\frac{1}{2}$ × ·38 6·42		$4\frac{1}{2}$	4	1	$8\frac{1}{2}$ × ·44 A = 11·2	8 × $3\frac{1}{2}$ × $3\frac{1}{2}$ × ·46 7·06		$5\frac{1}{2}$	5	1
40	10 × ·42 A = 12·5	9 × $3\frac{1}{2}$ × $3\frac{1}{2}$ × ·46 7·63		5	5	1	10 × ·46 A = 13·9	9 × $3\frac{1}{2}$ × $3\frac{1}{2}$ × ·52 8·17		6	6	1
50	11 × ·46	10 × $3\frac{1}{2}$ × $3\frac{1}{2}$ × ·50 8·59		$5\frac{1}{2}$	6	1	11 × ·50 A = 16·7	10 × $3\frac{1}{2}$ × $3\frac{1}{2}$ × ·60 9·59		$6\frac{1}{2}$	6	1
60	12 × ·50	10 × $3\frac{1}{2}$ × $3\frac{1}{2}$ × ·60 9·59		6	6	1	12 × ·52	10 × $3\frac{1}{2}$ × $3\frac{1}{2}$ × ·44 7·99	10 × ·42 A·20			
70	13 × ·54	10 × $3\frac{1}{2}$ × $3\frac{1}{2}$ × ·44 7·99	11 × ·42 4·62				14 × ·52 A = 21·2	10 × $3\frac{1}{2}$ × $3\frac{1}{2}$ × ·52 8·79	11 × ·46 5·06			
85	15 × ·54	10 × $3\frac{1}{2}$ × $3\frac{1}{2}$ × ·48 8·39	12 × ·50 6·80				15 × ·60	10 × $3\frac{1}{2}$ × $3\frac{1}{2}$ × ·56 9·19	12 × ·50 6·80			
100	17 × ·56	10 × $3\frac{1}{2}$ × $3\frac{1}{2}$ × ·50 8·59	12 × ·60 7·20				17 × ·60	12 × $3\frac{1}{2}$ × $3\frac{1}{2}$ × ·46 8·75	13 × ·60 7·80			
120	18 × ·60	12 × $3\frac{1}{2}$ × $3\frac{1}{2}$ × ·48 8·99	13 × ·70 9·10				18 × ·66	12 × $3\frac{1}{2}$ × $3\frac{1}{2}$ × ·50 9·73	13 × ·74 9·62			
140	18 × ·66						20 × ·66					
160	20 × ·66						22 × ·66					
180	22 × ·68						24 × ·70					
200	24 × ·72						26 × ·74					
220	26 × ·74						26 × ·78					
240	26 × ·78						28 × ·80					
260	28 × ·80						30 × ·80					

For Notes see page 134.

PILLARS.

TABLE 31

(SEE CONTINUATION.)

LENGTH AND FORM OF PILLAR.

Feet 16						Feet 20						NUMERAL.
TUBULAR.	DOUBLE CHANNELS AND FACE PLATES.		SOLID.			TUBULAR.	DOUBLE CHANNELS AND FACE PLATES.		SOLID.			
OUTSIDE DIAMETER.	CHANNELS.	FACE PLATES.	DIAMETER.	RIVETS IN ENDS.		OUTSIDE DIAMETER.	CHANNELS.	FACE PLATES.	DIAMETER.	RIVETS IN ENDS.		
Inches.	Inches.	Inches.	Inches.	No.	Inches.	Inches.	Inches.	Inches.	Inches.	No.	Inches.	
4 × ·36			$3\frac{1}{4}$	2	$\frac{7}{8}$	5 × ·36			$3\frac{7}{8}$	3	$\frac{7}{8}$	4
5 × ·36			$3\frac{3}{4}$	2	$\frac{7}{8}$	6 × ·38			$4\frac{1}{4}$	3	$\frac{7}{8}$	6
6 × ·38			4	3	$\frac{7}{8}$	7 × ·38			$4\frac{5}{8}$	3	$\frac{7}{8}$	8
7 × ·38 A = 8·00	6×3½×3½×·40 2 = 5·57		$4\frac{1}{2}$	3	$\frac{7}{8}$	8 × ·38	7×3½×3½×·46 2 × 6·50		$5\frac{1}{4}$	4	$\frac{7}{8}$	10
7½×·40 A = 8·9	7×3½×3½×·42 6·22		$5\frac{1}{4}$	4	$\frac{7}{8}$	8½×·40	8×3½×3½×·50 7·38		6	4	1	15
8½×·40 A = 10·2	8×3½×3½×·48 7·32		6	5	1	9 × ·44	9×3½×3½×·50 7·99					20
9 × ·44 A = 11·8 ·50	9×3½×3½×·50 7·99					10 × ·44	10×3½×3½×·50 8·59					30
10 × ·44 A = 15·0	10×3½×3½×·50 8·59					11 × ·50	9×3½×3½×·46 7·63	10×·40 4·00				40
12 × ·52 A = 18·8	9×3½×3½×·48 7·81	10×·42 4·20				13 × ·50	10×3½×3½×·48 8·39	11×·46 5·06				50
13 × ·54	10×3½×3½×·50 8·59	11×·46 5·06				14 × ·54	10×3½×3½×·56 9·19	12×·52 6·24				60
14 × ·58 A = 23·2	10×3½×3½×·56 9·19	12×·56 6·72				15 × ·58	10×3½×3½×·60 9·59	13×·60 7·80				70
16 × ·60	10×3½×3½×·60 9·59	13×·60 7·80				17 × ·58	12×3½×3½×·48 8·99	13×·72 9·36				85
18 × ·60	12×3½×3½×·50 9·25	13×·70 9·10				18 × ·64						100
19 × ·66						20 × ·66						120
22 × ·66						22 × ·70						140
23 × ·70						24 × ·70						160
24 × ·74						26 × ·76						180
26 × ·78						27 × ·80						200
27 × ·80						30 × ·80						220
30 × ·80						31 × ·84						240
31 × ·84												260

For Notes see page 134.

TABLE 31
(CONCLUDED.)

PILLARS.

NUMERAL.	LENGTH AND FORM OF PILLAR.											
	Feet 24						Feet 28					
	TUBULAR.	DOUBLE CHANNELS AND FACE PLATES.		SOLID.			TUBULAR.	DOUBLE CHANNELS AND FACE PLATES.		SOLID.		
	OUTSIDE DIAMETER.	CHANNELS.	FACE PLATES.	DIAMETER.	RIVETS IN ENDS.		OUTSIDE DIAMETER.	CHANNELS.	FACE PLATES.	DIAMETER.	RIVETS IN ENDS.	
	Inches.	Inches.	Inches.	Inches.	No.	Inches.	Inches.	Inches.	Inches.	Inches.	No.	Inches.
4	6 × ·38			$4\frac{3}{8}$	3	$\frac{7}{8}$	7 × ·38			$4\frac{7}{8}$	4	$\frac{7}{8}$
6	7 × ·38			$4\frac{3}{4}$	3	$\frac{7}{8}$	8 × ·38			$5\frac{1}{2}$	4	$\frac{7}{8}$
8	8 × ·38			$5\frac{1}{2}$	4	$\frac{7}{8}$	$8\frac{1}{2}$ × ·40			6	4	1
10	$8\frac{1}{2}$ × ·40	8 × $3\frac{1}{2}$ × $3\frac{1}{2}$ × ·50		6	4	1	9 × ·44	10 × $3\frac{1}{2}$ × $3\frac{1}{2}$ × ·50				
15	9 × ·44	9 × $3\frac{1}{2}$ × $3\frac{1}{2}$ × ·52					10 × ·44	10 × $3\frac{1}{2}$ × $3\frac{1}{2}$ × ·60				
20	10 × ·42	10 × $3\frac{1}{2}$ × $3\frac{1}{2}$ × ·52					10 × ·50	9 × $3\frac{1}{2}$ × $3\frac{1}{2}$ × ·46	10 × ·40			
30	10 × ·48	10 × $3\frac{1}{2}$ × $3\frac{1}{2}$ × ·60					11 × ·48	9 × $3\frac{1}{2}$ × $3\frac{1}{2}$ × ·48	11 × ·44			
40	12 × ·48	9 × $3\frac{1}{2}$ × $3\frac{1}{2}$ × ·48	11 × ·42				12 × ·52	10 × $3\frac{1}{2}$ × $3\frac{1}{2}$ × ·50	11 × ·46			
50	13 × ·54	10 × $3\frac{1}{2}$ × $3\frac{1}{2}$ × ·52	12 × ·50				14 × ·52	10 × $3\frac{1}{2}$ × $3\frac{1}{2}$ × ·60	12 × ·56			
60	14 × ·58	10 × $3\frac{1}{2}$ × $3\frac{1}{2}$ × ·56	12 × ·60				15 × ·56	12 × $3\frac{1}{2}$ × $3\frac{1}{2}$ × ·46	13 × ·64			
70	16 × ·56	10 × $3\frac{1}{2}$ × $3\frac{1}{2}$ × ·60	13 × ·70				16 × ·62	12 × $3\frac{1}{2}$ × $3\frac{1}{2}$ × ·50	13 × ·74			
85	17 × ·64	12 × $3\frac{1}{2}$ × $3\frac{1}{2}$ × ·46	13 × ·74				18 × ·62					
100	19 × ·64						19 × ·68					
120	20 × ·70						21 × ·70					
140	23 × ·70											
160	25 × ·74											
180	27 × ·78											
200	29 × ·80											
220												
240												
260												

NOTES.—TABLE 31.

1. The Numeral for use in the Table is to be the sum of the Numerals representing the separate loads which may be transmitted to the pillar, namely :

(*a*) The Numeral in respect of that proportion of the deck load, supported by a girder, hatch end beam or deck transverse, which is borne by the pillar.

(*b*) The Numeral of the directly superimposed pillar, if any.

2. The Numeral is to be determined by :

$$\frac{s \times b \times h}{100}$$

where s = the distance in feet between the centres of the two adjacent spans of girder supported by the pillar.

b = the mean width of deck, including hatchway if necessary, supported by the girders over the distance s.

h is to be measured as defined in **Table 29, Note 1.**

3. Pillars equivalent to those shown in the Tables, of riveted or welded construction, will be accepted.

When hollow square pillars are fitted, the thickness is to be the same as that of the tubular pillar required and the side is to be 80 per cent of the diameter of the tubular pillar.

4. When solid pillars are fitted in pairs to take shifting boards, their diameter is to be 75 per cent of that required by the Table.

5. For end connections and constructional details ***see*** **Section 15, clause 7.**

TABLE 32

BULKHEAD PLATING

Stiffeners spaced 30 inches apart on Watertight Bulkheads and 24 inches apart on Collision, Deep Tank, Peak Tank and Oil Fuel Bunker Bulkheads.

DEPTH. (*See* Note 1)	THICKNESS.	DEPTH. (*See* Note 1)	THICKNESS.
Feet.	Inches.	Feet.	Inches.
8	·26	36	·40
12	·28	40	·42
16	·30	44	·44
20	·32	48	·46
24	·34	52	·48
28	·36	56	·50
32	·38	60	·52

FOR RULE HEIGHT OF AIRPIPES SEE PAGE 56.

NOTES.—TABLE 32.

1. **Depth** is to be measured as follows :—

(*a*) **For Watertight Bulkheads (Section 16).**—From the lower edge of the plate to the top of the bulkhead at the centre line.

(*b*) **For Bulkheads of Tanks (Sections 19 and 20).**—From the lower edge of the plate to the top of the tank or to a point midway between the half-depth of the tank and the top of the overflow, whichever distance is greater.

2. **Correction for Spacing of Stiffeners.**—Where the spacing of stiffeners differs from that given in the Table the thickness of the plating is to be modified at the rate of 2 per cent for every inch of difference except that where the spacing on tank or oil bunker bulkheads exceeds 24 inches the thickness is to be increased at the rate of 3 per cent per inch difference of spacing.

3. **Additions to Thickness**, as corrected by Note 2, are to be made as follows :—

(*a*) To the lowest strake of hold and tank bulkheads ... ... ·04 inch.

(*b*) To the lowest strake of stokehold bulkheads in coal burning ships ... ... ·10 inch.

(*c*) Plates in limbers and at the bottom of peak bulkheads ... ... ·10 inch.

(*d*) In way of the stern tube, plating to be increased substantially or doubled.

4. The plating of deep tank, peak tank and oil fuel bunker bulkheads in ships exceeding 150 feet in length is not to be less than ·30 inch after correction.

TABLE 33

(SEE CONTINUATION.)

BULKHEAD STIFFENER

Spaced 24 inches apart on collision bulkhea

LENGTH OF STIFFENER.	HEIGHT OF TOP OF BULKHEAD AT MIDDLE LINE ABOVE TOP OF STIFFENER. FEET.						
	0	2	4	6	8	10	12
Feet.	INCHES *Modulus—Inches*³						
8	4 × 3 × ·30 *1·65*	4 × 3 × ·38 *2·10*	4 × 3 × ·43 *2·35*	5 × 3 × ·32 *2·70*	5 × 3 × ·39 *3·25*	5 × 3 × ·44 *3·65*	6 × 3 × ·34 *4·10*
9	4 × 3 × ·40 *2·20*	5 × 3 × ·32 *2·70*	5 × 3 × ·36 *3·00*	5 × 3 × ·44 *3·65*	6 × 3 × ·36 *4·30*	6 × 3 × ·38 *4·55*	5½ × 3 × ·34 *5·60*
10	5 × 3 × ·34 *2·85*	5 × 3 × ·42 *3·50*	6 × 3 × ·34 *4·10*	6 × 3 × ·38 *4·55*	5½ × 3 × ·34 *5·60*	6 × 3 × ·35 *6·95*	6 × 3 × ·36 *7·10*
11	5 × 3 × ·44 *3·65*	6 × 3 × ·36 *4·30*	5½ × 3 × ·34 *5·60*	5½ × 3 × ·38 *6·05*	6 × 3 × ·35 *6·95*	6 × 3 × ·45 *8·35*	6 × 3 × ·47 *8·60*
12	6 × 3 × ·38 *4·55*	5½ × 3 × ·36 *5·80*	6 × 3 × ·35 *6·95*	6 × 3 × ·38 *7·35*	6 × 3 × ·47 *8·60*	7 × 3 × ·37 *10·10*	7 × 3 × ·39 *10·45*
13	5½ × 3 × ·37 *5·95*	6 × 3 × ·36 *7·10*	6 × 3 × ·45 *8·35*	6 × 3 × ·48 *8·75*	7 × 3 × ·39 *10·45*	7 × 3 × ·48 *12·05*	7 × 3 × ·49 *12·25*
14	6 × 3 × ·36 *7·10*	6 × 3 × ·45 *8·35*	7 × 3 × ·37 *10·10*	7 × 3 × ·40 *10·60*	7 × 3 × ·49 *12·25*	8 × 3 × ·39 *14·10*	8 × 3 × ·42 *14·75*
15	6 × 3 × ·45 *8·35*	7 × 3 × ·37 *10·10*	7 × 3 × ·48 *12·05*	7 × 3 × ·51 *12·60*	8 × 3 × ·41 *14·55*	8 × 3 × ·49 *16·35*	8 × 3 × ·52 *17·10*
16	7 × 3 × ·37 *10·10*	7 × 3 × ·48 *12·05*	8 × 3 × ·39 *14·10*	8 × 3 × ·42 *14·75*	8 × 3 × ·51 *16·85*	9 × 3½ × ·41 *19·15*	9 × 3½ × ·44 *19·90*
17	7 × 3 × ·48 *12·05*	8 × 3 × ·39 *14·10*	8 × 3 × ·49 *16·35*	8 × 3 × ·52 *17·10*	9 × 3½ × ·43 *19·65*	9 × 3½ × ·51 *21·90*	9 × 3½ × ·52 *22·20*
18	8 × 3 × ·39 *14·10*	8 × 3 × ·49 *16·35*	9 × 3½ × ·41 *19·15*	9 × 3½ × ·44 *19·90*	9 × 3½ × ·51 *21·90*	10 × 3½ × ·41 *24·50*	10 × 3½ × ·50 *27·40*
19	8 × 3 × ·49 *16·35*	9 × 3½ × ·41 *19·15*	9 × 3½ × ·45 *20·20*	9 × 3½ × ·52 *22·20*	10 × 3½ × ·42 *24·80*	10 × 3½ × ·52 *28·10*	*30·90*
20	9 × 3½ × ·41 *19·15*	9 × 3½ × ·51 *21·90*	10 × 3½ × ·41 *24·50*	10 × 3½ × ·53 *28·45*	10 × 3½ × ·55 *29·15*	*30·90*	11 × 3½ × ·53 *35·00*
21	9 × 3½ × ·51 *21·90*	10 × 3½ × ·41 *24·50*	10 × 3½ × ·50 *27·40*	*30·90*	11 × 3½ × ·44 *31·55*	11 × 3½ × ·54 *35·40*	11 × 3½ × ·61 *38·20*
22	10 × 3½ × ·41 *24·50*	10 × 3½ × ·50 *27·40*	*30·90*	11 × 3½ × ·51 *34·20*	11 × 3½ × ·60 *37·80*	11 × 3½ × ·63 *39·00*	12 × 3½ × ·51 *41·65*
23	10 × 3½ × ·50 *27·40*	*30·90*	11 × 3½ × ·51 *34·20*	11 × 3½ × ·60 *37·80*	12 × 3½ × ·46 *39·45*	12 × 3½ × ·51 *41·65*	12 × 4 × 4 × ·46 *45·40*
24	*30·90*	11 × 3½ × ·51 *34·20*	11 × 3½ × ·60 *37·80*	12 × 3½ × ·51 *41·65*	12 × 3½ × ·54 *43·05*	12 × 4 × 4 × ·48 *46·20*	12 × 4 × 4 × ·54 *48·60*
25	11 × 3½ × ·51 *34·20*	11 × 3½ × ·60 *37·80*	12 × 3½ × ·51 *41·65*	12 × 3½ × ·58 *44·95*	12 × 4 × 4 × ·50 *47·00*	12 × 4 × 4 × ·62 *51·80*	12 × 4 × 4 × ·67 *53·75*
26	11 × 3½ × ·60 *37·80*	12 × 3½ × ·51 *41·65*	12 × 3½ × ·58 *44·95*	12 × 4 × 4 × ·54 *48·60*	12 × 4 × 4 × ·64 *52·60*	*55·50*	
27	12 × 3½ × ·51 *41·65*	12 × 3½ × ·54 *43·05*	12 × 4 × 4 × ·50 *47·00*	*54·50*	*58·60*		

ANGLES — BULB ANGLES

For Notes see page 143.

Section moduli above a

—BRACKETED.

TABLE 33

(SEE CONTINUATION.)

nd 30 inches apart on other watertight bulkheads.

HEIGHT OF TOP OF BULKHEAD AT MIDDLE LINE ABOVE TOP OF STIFFENER. FEET.							LENGTH OF STIFFENER.	
14	16	18	20	22	24	26		
INCHES *Modulus—Inches*^{3}							Feet.	
6 × 3 × ·36 *4·30*	5½ × 3 × ·28 *4·95*	5½ × 3 × ·34 *5·60*	5½ × 3 × ·37 *5·95*	6 × 3 × ·35 *6·95*	6 × 3 × ·36 *7·10*	6 × 3 × ·39 *7·50*	BULB ANGLES	8
5½ × 3 × ·37 *5·95*	6 × 3 × ·35 *6·95*	6 × 3 × ·36 *7·10*	6 × 3 × ·45 *8·35*	6 × 3 × ·48 *8·75*	6 × 3 × ·50 *9·00*	7 × 3 × ·37 *10·10*		9
6 × 3 × ·38 *7·35*	6 × 3 × ·45 *8·35*	6 × 3 × ·48 *8·75*	7 × 3 × ·37 *10·10*	7 × 3 × ·40 *10·60*	7 × 3 × ·48 *12·05*	7 × 3 × ·49 *12·25*		10
7 × 3 × ·36 *9·95*	7 × 3 × ·39 *10·45*	7 × 3 × ·48 *12·05*	7 × 3 × ·49 *12·25*	8 × 3 × ·39 *14·10*	8 × 3 × ·41 *14·55*	8 × 3 × ·42 *14·75*		11
7 × 3 × ·48 *12·05*	7 × 3 × ·49 *12·25*	8 × 3 × ·39 *14·10*	8 × 3 × ·41 *14·55*	8 × 3 × ·49 *16·35*	8 × 3 × ·51 *16·85*	9 × 3½ × ·38 *18·40*		12
8 × 3 × ·39 *14·10*	8 × 3 × ·42 *14·75*	8 × 3 × ·53 *17·35*	9 × 3½ × ·41 *19·15*	9 × 3½ × ·43 *19·65*	9 × 3½ × ·44 *19·90*	9 × 3½ × ·51 *21·50*		13
8 × 3 × ·49 *16·35*	9 × 3½ × ·38 *18·40*	9 × 3½ × ·41 *19·15*	9 × 3½ × ·49 *21·35*	9 × 3½ × ·51 *21·90*	10 × 3½ × ·41 *24·50*	10 × 3½ × ·42 *24·80*		14
9 × 3½ × ·41 *19·15*	9 × 3½ × ·45 *20·20*	9 × 3½ × ·51 *21·90*	10 × 3½ × ·41 *24·50*	10 × 3½ × ·50 *27·40*	10 × 3½ × ·52 *28·10*	*30·90*		15
9 × 3½ × ·51 *21·90*	10 × 3½ × ·41 *24·50*	10 × 3½ × ·50 *27·40*	10 × 3½ × ·53 *28·45*	*30·90*	11 × 3½ × ·44 *31·55*	11 × 3½ × ·53 *35·00*		16
10 × 3½ × ·42 *24·80*	10 × 3½ × ·52 *28·10*	*30·90*	11 × 3½ × ·53 *35·00*	11 × 3½ × ·54 *35·40*	11 × 3½ × ·60 *37·80*	11 × 3½ × ·61 *38·20*		17
30·90	11 × 3½ × ·44 *31·55*	11 × 3½ × ·53 *35·00*	11 × 3½ × ·60 *37·80*	11 × 3½ × ·61 *38·20*	12 × 3½ × ·51 *41·65*	12 × 3½ × ·54 *43·05*		18
11 × 3½ × ·53 *35·00*	11 × 3½ × ·60 *37·80*	11 × 3½ × ·61 *38·20*	12 × 3½ × ·51 *41·65*	12 × 3½ × ·52 *42·10*	12 × 3½ × ·56 *44·00*	12×4×4×·48 *46·20*	CHANNELS	19
11 × 3½ × ·60 *37·80*	12 × 3½ × ·46 *39·45*	12 × 3½ × ·51 *41·65*	12 × 3½ × ·56 *44·00*	12 × 4 × 4 × ·48 *46·20*	12 × 4 × 4 × ·52 *47·80*	12×4×4×·62 *51·80*		20
12 × 3½ × ·51 *41·65*	12 × 3½ × ·52 *42·10*	12 × 4 × 4 × ·48 *46·20*	12 × 4 × 4 × ·50 *47·00*	12 × 4 × 4 × ·62 *51·80*	12 × 4 × 4 × ·67 *53·75*	*57·50*		21
12 × 3½ × ·58 *44·95*	12 × 4 × 4 × ·48 *46·20*	12 × 4 × 4 × ·62 *51·80*	12 × 4 × 4 × ·64 *52·60*	*57·50*	*59·70*	15×4×4×·48 *64·60*		22
12 × 4 × 4 × ·50 *47·00*	12 × 4 × 4 × ·62 *51·80*	*57·50*	*58·60*	15 × 4 × 4 × ·46 *63·35*	15 × 4 × 4 × ·50 *65·85*			23
12 × 4 × 4 × ·64 *52·60*	*57·50*	15 × 4 × 4 × ·46 *63·35*	15 × 4 × 4 × ·48 *64·60*					24
								25
								26
								27

For Notes see page 143.

given to nearest ·05.

TABLE 33

(CONCLUDED.)

BULKHEAD STIFFENERS—BRACKETED.

Spaced 24 inches apart on collision bulkheads and 30 inches apart on other watertight bulkheads.

LENGTH OF STIFFENER.	HEIGHT OF TOP OF BULKHEAD AT MIDDLE LINE ABOVE TOP OF STIFFENER. FEET.						
	28	30	32	34	36	38	40
Feet.	INCHES *Modulus—Inches*^{3}						
8	6 × 3 × ·45 *8·35*	6 × 3 × ·47 *8·60*	6 × 3 × ·48 *8·75*	7 × 3 × ·37 *10·10*	7 × 3 × ·38 *10·25*	7 × 3 × ·40 *10·60*	7 × 3 × ·48 *12·05*
9	7 × 3 × ·40 *10·60*	7 × 3 × ·47 *11·85*	7 × 3 × ·48 *12·05*	7 × 3 × ·49 *12·25*	8 × 3 × ·38 *13·85*	8 × 3 × ·39 *14·10*	8 × 3 × ·41 *14·55*
10	7 × 3 × ·51 *12·60*	8 × 3 × ·39 *14·10*	8 × 3 × ·41 *14·55*	8 × 3 × ·48 *16·10*	8 × 3 × ·49 *16·35*	8 × 3 × ·52 *17·10*	9 × 3½ × ·41 *19·15*
11	8 × 3 × ·49 *16·35*	8 × 3 × ·51 *16·85*	9 × 3½ × ·41 *19·15*	9 × 3½ × ·43 *19·65*	9 × 3½ × ·44 *19·90*	9 × 3½ × ·45 *20·20*	9 × 3½ × ·51 *21·90*
12	9 × 3½ × ·41 *19·15*	9 × 3½ × ·45 *20·20*	9 × 3½ × ·51 *21·90*	9 × 3½ × ·52 *22·20*	10 × 3½ × ·41 *24·50*	10 × 3½ × ·44 *25·45*	10 × 3½ × ·50 *27·40*
13	9 × 3½ × ·52 *22·20*	10 × 3½ × ·41 *24·50*	10 × 3½ × ·42 *24·80*	10 × 3½ × ·50 *27·40*	10 × 3½ × ·53 *28·45*	*30·90*	11 × 3½ × ·44 *31·55*
14	10 × 3½ × ·50 *27·40*	10 × 3½ × ·53 *28·45*	*30·90*	11 × 3½ × ·51 *34·20*	11 × 3½ × ·53 *35·00*	11 × 3½ × ·54 *35·40*	11 × 3½ × ·60 *37·80*
15	11 × 3½ × ·44 *31·55*	11 × 3½ × ·51 *34·20*	11 × 3½ × ·54 *35·40*	11 × 3½ × ·60 *37·80*	11 × 3½ × ·61 *38·20*	11 × 3½ × ·63 *39·00*	12 × 3½ × ·51 *41·65*
16	11 × 3½ × ·60 *37·80*	11 × 3½ × ·61 *38·20*	11 × 3½ × ·63 *39·00*	12 × 3½ × ·51 *41·65*	12 × 3½ × ·52 *42·10*	12 × 3½ × ·54 *43·05*	12×4×4×·48 *46·20*
17	12 × 3½ × ·51 *41·65*	12 × 3½ × ·52 *42·10*	12 × 3½ × ·54 *43·05*	12 × 4 × 4 × ·48 *46·20*	12 × 4 × 4 × ·50 *47·00*	12 × 4 × 4 × ·52 *47·80*	12×4×4×·62 *51·80*
18	12 × 3½ × ·56 *44·00*	12 × 4 × 4 × ·48 *46·20*	12 × 4 × 4 × ·50 *47·00*	12 × 4 × 4 × ·62 *51·80*	12 × 4 × 4 × ·64 *52·60*	12 × 4 × 4 × ·67 *53·75*	*57·50*
19	12×4×4×·52 *47·80*	12 × 4 × 4 × ·62 *51·80*	12 × 4 × 4 × ·64 *52·60*	*57·50*	*58·60*	15 × 4 × 4 × ·46 *63·35*	15×4×4×·48 *64·60*
20	12×4×4×·67 *53·75*	*57·50*	*58·60*	15 × 4 × 4 × ·46 *63·35*	15 × 4 × 4 × ·48 *64·60*		
21	*59·70*	15 × 4 × 4 × ·46 *63·35*	15 × 4 × 4 × ·50 *65·85*				
22	15×4×4×·50 *65·85*						
23							
24							
25							
26							
27							

BULB ANGLES — CHANNELS

BULB ANGLES — CHANNELS

For Notes see page 143.

Section moduli above are given to nearest ·05.

TABLE 34

(SEE CONTINUATION.)

BULKHEAD STIFFENERS

Spaced 24 inches apart on collision bulkhead

LENGTH OF STIFFENER.		HEIGHT OF TOP OF BULKHEAD AT MIDDLE LINE ABOVE TOP OF STIFFENER. FEET.						
		0	2	4	6	8	10	12
Feet.		INCHES *Modulus—Inches*³						
8	ANGLES	*4 × 3 × ·43 *2·35*	5 × 3 × ·36 *3·00*	5 × 3 × ·46 *3·80*	6 × 3 × ·38 *4·55*	5½ × 3 × ·36 *5·80*	5½ × 3 × ·38 *6·05*	6 × 3 × ·35 *6·95*
9	ANGLES	*5 × 3 × ·42 *3·50*	5 × 3 × ·47 *3·90*	5½ × 3 × ·36 *5·80*	5½ × 3 × ·38 *6·05*	6 × 3 × ·35 *6·95*	6 × 3 × ·39 *7·50*	6 × 3 × ·46 *8·45*
10	ANGLES	*6 × 3 × ·38 *4·55*	5½ × 3 × ·37 *5·95*	6 × 3 × ·35 *6·95*	6 × 3 × ·45 *8·35*	6 × 3 × ·48 *8·75*	7 × 3 × ·37 *10·10*	7 × 3 × ·40 *10·60*
11	BULB ANGLES	5½ × 3 × ·38 *6·05*	6 × 3 × ·38 *7·35*	6 × 3 × ·46 *8·45*	7 × 3 × ·37 *10·10*	7 × 3 × ·40 *10·60*	7 × 3 × ·49 *12·25*	8 × 3 × ·39 *14·10*
12	BULB ANGLES	6 × 3 × ·39 *7·50*	6 × 3 × ·50 *9·00*	7 × 3 × ·39 *10·45*	7 × 3 × ·48 *12·05*	7 × 3 × ·54 *13·15*	8 × 3 × ·42 *14·75*	8 × 3 × ·51 *16·85*
13	BULB ANGLES	6 × 3 × ·45 *8·35*	7 × 3 × ·40 *10·60*	7 × 3 × ·51 *12·60*	8 × 3 × ·41 *14·55*	8 × 3 × ·49 *16·35*	9 × 3½ × ·41 *19·15*	9 × 3½ × ·44 *19·90*
14	BULB ANGLES	7 × 3 × ·41 *10·80*	7 × 3 × ·52 *12·80*	8 × 3 × ·49 *16·35*	8 × 3 × ·53 *17·35*	9 × 3½ × ·43 *19·65*	9 × 3½ × ·51 *21·90*	9 × 3½ × ·54 *22·70*
15	BULB ANGLES	7 × 3 × ·52 *12·80*	8 × 3 × ·45 *15·45*	9 × 3½ × ·41 *19·15*	9 × 3½ × ·45 *20·20*	9 × 3½ × ·52 *22·20*	10 × 3½ × ·42 *24·80*	10 × 3½ × ·50 *27·40*
16	BULB ANGLES	8 × 3 × ·49 *16·35*	9 × 3½ × ·41 *19·15*	9 × 3½ × ·51 *21·90*	10 × 3½ × ·41 *24·50*	10 × 3½ × ·45 *25·80*	10 × 3½ × ·55 *29·15*	11 × 3½ × ·44 *31·55*
17	BULB ANGLES	9 × 3½ × ·43 *19·65*	9 × 3½ × ·51 *21·90*	10 × 3½ × ·42 *24·80*	10 × 3½ × ·52 *28·10*	*30·90*	11 × 3½ × ·46 *32·30*	11 × 3½ × ·56 *36·20*
18	BULB ANGLES	9 × 3½ × ·51 *21·90*	10 × 3½ × ·44 *25·45*	10 × 3½ × ·55 *29·15*	11 × 3½ × ·44 *31·55*	11 × 3½ × ·55 *35·80*	11 × 3½ × ·61 *38·20*	12 × 3½ × ·51 *41·65*
19	BULB ANGLES	10 × 3½ × ·42 *24·80*	10 × 3½ × ·53 *28·45*	11 × 3½ × ·45 *31·95*	11 × 3½ × ·58 *37·00*	11 × 3½ × ·63 *39·00*	12 × 3½ × ·51 *41·65*	12 × 4 × 4 × ·48 *46·20*
20	BULB ANGLES	*30·90*	11 × 3½ × ·46 *32·30*	11 × 3½ × ·60 *37·80*	12 × 3½ × ·51 *41·65*	12 × 3½ × ·52 *42·10*	12 × 4 × 4 × ·48 *46·20*	13 × 4 × 4 × ·62 *51·80*
21	BULB ANGLES	11 × 3½ × ·46 *32·30*	11 × 3½ × ·60 *37·80*	12 × 3½ × ·51 *41·65*	12 × 3½ × ·56 *44·00*	12 × 4 × 4 × ·48 *46·20*	12 × 4 × 4 × ·62 *51·80*	*57·50*
22	BULB ANGLES	11 × 3½ × ·60 *37·80*	12 × 3½ × ·51 *41·65*	12 × 3½ × ·56 *44·00*	12 × 4 × 4 × ·52 *47·80*	12 × 4 × 4 × ·62 *51·80*	*57·50*	15 × 4 × 4 × ·46 *63·35*
23	BULB ANGLES	12 × 3½ × ·51 *41·65*	12 × 3½ × ·58 *44·95*	12 × 4 × 4 × ·54 *48·60*	12 × 4 × 4 × ·67 *53·75*	*57·50*	15 × 4 × 4 × ·46 *63·35*	
24	BULB ANGLES	12 × 3½ × ·58 *44·95*	12 × 4 × 4 × ·56 *49·40*	*54·50*	*59·70*	15 × 4 × 4 × ·48 *64·60*		
25	CHANNELS	12×4×4×·54 *48·60*	*55·50*	*60·80*	15 × 4 × 4 × ·50 *65·85*			
26	CHANNELS	*54·50*	15 × 4 × 4 × ·44 *62·15*	15 × 4 × 4 × ·53 *67·65*				
27	CHANNELS	*60·80*	15 × 4 × 4 × ·55 *68·85*					

The ends of upper 'tween deck stiffeners marked * may be riveted to the boundary angle only, without lug attachment.

Section moduli above

LUGGED.

TABLE 34

(SEE CONTINUATION.)

and 30 inches apart on other watertight bulkheads.

HEIGHT OF TOP OF BULKHEAD AT MIDDLE LINE ABOVE TOP OF STIFFENER. FEET. 14	16	18	20	22	24	26		LENGTH OF STIFFENER.
INCHES *Modulus—Inches³*								Feet.
6 × 3 × ·40 *7·65*	6 × 3 × ·47 *8·35*	6 × 3 × ·48 *8·75*	7 × 3 × ·37 *10·10*	7 × 3 × ·39 *10·45*	7 × 3 × ·41 *10·80*	7 × 3 × ·48 *12·05*	BULB ANGLES.	8
7 × 3 × ·37 *10·10*	7 × 3 × ·40 *10·60*	7 × 3 × ·43 *11·15*	7 × 3 × ·49 *12·25*	8 × 3 × ·39 *14·10*	8 × 3 × ·41 *14·55*	8 × 3 × ·49 *16·35*		9
7 × 3 × ·48 *12·05*	7 × 3 × ·52 *12·80*	8 × 3 × ·41 *14·55*	8 × 3 × ·49 *16·35*	8 × 3 × ·52 *17·10*	9 × 3½ × ·41 *19·15*	9 × 3½ × ·43 *19·65*		10
8 × 3 × ·42 *14·75*	8 × 3 × ·49 *16·35*	8 × 3 × ·53 *17·35*	9 × 3½ × ·43 *19·65*	9 × 3½ × ·45 *20·20*	9 × 3½ × ·51 *21·90*	10 × 3½ × ·41 *24·50*		11
9 × 3½ × ·41 *19·15*	9 × 3½ × ·43 *19·65*	9 × 3½ × ·51 *21·90*	9 × 3½ × ·54 *22·70*	10 × 3½ × ·42 *24·80*	10 × 3½ × ·46 *26·10*	10 × 3½ × ·50 *27·40*		12
9 × 3½ × ·51 *21·90*	9 × 3½ × ·54 *22·70*	10 × 3½ × ·44 *25·45*	10 × 3½ × ·52 *28·10*	*30·90*	11 × 3½ × ·44 *31·55*	11 × 3½ × ·53 *35·00*		13
10 × 3½ × ·44 *25·45*	10 × 3½ × ·52 *28·10*	*30·90*	11 × 3½ × ·45 *31·95*	11 × 3½ × ·55 *35·80*	11 × 3½ × ·60 *37·80*	12 × 3½ × ·46 *39·45*		14
30·90	11 × 3½ × ·45 *31·95*	11 × 3½ × ·55 *35·80*	11 × 3½ × ·60 *37·80*	12 × 3½ × ·51 *41·65*	12 × 3½ × ·52 *42·10*	12 × 3½ × ·56 *44·00*		15
11 × 3½ × ·45 *31·95*	11 × 3½ × ·60 *37·80*	12 × 3½ × ·46 *39·45*	12 × 3½ × ·51 *41·65*	12 × 3½ × ·58 *44·95*	12 × 4 × 4 × ·48 *46·20*	12×4×4×·62 *51·80*	CHANNELS	16
11 × 3½ × ·63 *39·00*	12 × 3½ × ·51 *41·65*	12 × 3½ × ·58 *44·95*	12 × 4 × 4 × ·48 *46·20*	12 × 4 × 4 × ·62 *51·80*	12 × 4 × 4 × ·64 *52·60*	*57·50*		17
12 × 3½ × ·54 *43·05*	12 × 4 × 4 × ·48 *46·20*	12 × 4 × 4 × ·62 *51·80*	12 × 4 × 4 × ·64 *52·60*	*57·50*	*59·70*	15×4×4×·48 *64·60*		18
12 × 4 × 4 × ·52 *47·80*	12 × 4 × 4 × ·62 *51·80*	*57·50*	*59·70*	15 × 4 × 4 × ·46 *63·35*				19
12 × 4 × 4 × ·67 *53·75*	*57·50*	15 × 4 × 4 × ·46 *63·35*	15 × 4 × 4 × ·53 *67·65*					20
59·70	15 × 4 × 4 × ·50 *65·85*							21
								22
								23
								24
								25
								26
								27

For Notes see page 143.

given to nearest ·05.

TABLE 34 (CONCLUDED.) BULKHEAD STIFFENERS—LUGGED.

Spaced 24 inches apart on collision bulkheads and 30 inches apart on other watertight bulkheads.

LENGTH OF STIFFENER.	HEIGHT OF TOP OF BULKHEAD AT MIDDLE LINE ABOVE TOP OF STIFFENER. FEET.						
	28	30	32	34	36	38	40
Feet.	INCHES *Modulus—Inches³*						
8	7 × 3 × ·52 *12·80*	8 × 3 × ·39 *14·10*	8 × 3 × ·41 *14·55*	8 × 3 × ·43 *15·00*	8 × 3 × ·51 *16·85*	8 × 3 × ·52 *17·10*	8 × 3 × ·53 *17·35*
9	8 × 3 × ·52 *17·10*	8 × 3 × ·53 *17·35*	9 × 3½ × ·41 *19·15*	9 × 3½ × ·43 *19·65*	9 × 3½ × ·45 *20·20*	9 × 3½ × ·51 *21·90*	9 × 3½ × ·52 *22·20*
10	9 × 3½ × ·45 *20·20*	9 × 3½ × ·51 *21·90*	9 × 3½ × ·52 *22·20*	10 × 3½ × ·41 *24·50*	10 × 3½ × ·42 *24·80*	10 × 3½ × ·50 *27·40*	10 × 3½ × ·53 *28·45*
11	10 × 3½ × ·42 *24·80*	10 × 3½ × ·50 *27·40*	10 × 3½ × ·53 *28·45*	*30·90*	11 × 3½ × ·44 *31·55*	11 × 3½ × ·45 *31·95*	11 × 3½ × ·53 *35·00*
12	*30·90*	11 × 3½ × ·45 *31·95*	11 × 3½ × ·53 *35·00*	11 × 3½ × ·55 *35·80*	11 × 3½ × ·60 *37·80*	11 × 3½ × ·63 *39·00*	12 × 3½ × ·51 *41·65*
13	11 × 3½ × ·55 *35·80*	11 × 3½ × ·60 *37·80*	12 × 3½ × ·46 *39·45*	12 × 3½ × ·51 *41·65*	12 × 3½ × ·52 *42·10*	12 × 3½ × ·54 *43·05*	12×4×4×·48 *46·20*
14	12 × 3½ × ·51 *41·65*	12 × 3½ × ·52 *42·10*	12 × 3½ × ·58 *44·95*	12 × 4 × 4 × ·48 *46·20*	12 × 4 × 4 × ·50 *47·00*	12 × 4 × 4 × ·62 *51·80*	*57·50*
15	12×4×4×·48 *46·20*	12 × 4 × 4 × ·52 *47·80*	12 × 4 × 4 × ·62 *51·80*	12 × 4 × 4 × ·64 *52·60*	*57·50*	*58·60*	15×4×4×·46 *63·35*
16	12×4×4×·64 *52·60*	*57·50*	*58·60*	15 × 4 × 4 × ·46 *63·35*	15 × 4 × 4 × ·48 *64·60*	15 × 4 × 4 × ·50 *65·85*	
17	*59·70*	15 × 4 × 4 × ·46 *63·35*	15 × 4 × 4 × ·50 *65·85*				
18	15×4×4×·53 *67·65*						
19							
20							
21							
22							
23							
24							
25							
26							
27							

BULB ANGLES — CHANNELS — BULB ANGLES — CHANNELS

For Notes see page 143.

Section moduli above are given to nearest ·05.

TABLE 35

BULKHEAD STIFFENERS in TUGS.

Spaced 24 inches apart on collision bulkheads and 30 inches apart on other watertight bulkheads.

LENGTH OF STIFFENER.		STIFFENERS BRACKETED AT ENDS.	STIFFENERS WITHOUT BRACKETS OR LUGS AT ENDS.
Feet.		INCHES *Modulus—Inches³*	INCHES *Modulus—Inches³*
7	ANGLES ↑	—	$3\frac{1}{2}\times2\frac{1}{2}\times\cdot30$ *1·30*
8		$3\times2\frac{1}{2}\times\cdot28$ *·90*	$4\times3\times\cdot30$ *1·65*
9		$3\times2\frac{1}{2}\times\cdot30$ *1·00*	$4\times3\times\cdot34$ *1·90*
10		$3\frac{1}{2}\times2\frac{1}{2}\times\cdot32$ *1·40*	$4\times3\times\cdot43$ *2·35*
11		$4\times3\times\cdot32$ *1·80*	$5\times3\times\cdot34$ *2·85*
12		$4\times3\times\cdot40$ *2·20*	$5\times3\times\cdot42$ *3·50*
13		$5\times3\times\cdot32$ *2·70*	$6\times3\times\cdot36$ *4·30*
14		$5\times3\times\cdot42$ *3·50*	$6\times3\times\cdot42$ *5·00*
15		$6\times3\times\cdot36$ *4·30*	$6\times3\times\cdot49$ *5·75*
16	↓	$6\times3\times\cdot42$ *5·00*	—

TABLE 36

END ATTACHMENTS for STIFFENERS.

TYPE AND DEPTH OF STIFFENER.		BRACKET ATTACHMENTS.			LUG ATTACHMENTS.
		Thickness of Bracket.	Width of Flange.	Number and Size of Rivets in each Arm of Bracket.	Number and Size of Rivets in Lugs.
		Inches.	Inches.		
Angles		·34	—	3 of $\frac{3}{4}$ Ins. Dia.	2 of $\frac{3}{4}$ Ins. Dia.
Bulb Angles 6 inches & under		·36	—	3 „ $\frac{3}{4}$ „ „	2 „ $\frac{3}{4}$ „ „
Bulb Angles 7 inches		·40	—	4 „ $\frac{3}{4}$ „ „	3 „ $\frac{3}{4}$ „ „
„ „ 8 „		·42	—	5 „ $\frac{3}{4}$ „ „	3 „ $\frac{3}{4}$ „ „
„ „ 9 „	FLANGED ↑	·34	$2\frac{1}{4}$	6 „ $\frac{3}{4}$ „ „	4 „ $\frac{3}{4}$ „ „
„ „ 10 „		·36	$2\frac{1}{2}$	7 „ $\frac{3}{4}$ „ „	4 „ $\frac{3}{4}$ „ „
„ „ 11 „		·38	$2\frac{3}{4}$	7 „ $\frac{7}{8}$ „ „	4 „ $\frac{7}{8}$ „ „
„ „ 12 „		·40	3	8 „ $\frac{7}{8}$ „ „	5 „ $\frac{7}{8}$ „ „
Channels $12\times3\frac{1}{2}\times3\frac{1}{2}$ inches		·40	3	9 „ $\frac{7}{8}$ „ „	6 „ $\frac{7}{8}$ „ „
„ $12\times4\times4$ „		·40	3	10 „ $\frac{7}{8}$ „ „	7 „ $\frac{7}{8}$ „ „
„ $15\times4\times4$ „	↓	·44	$3\frac{1}{2}$	13 „ $\frac{7}{8}$ „ „	8 „ $\frac{7}{8}$ „ „

THICKNESS OF BKT TO BE USED IN DETERMINING LEG LENGTH OF STAGGERED WELDS SHOULD BE THAT REQUIRED BEFORE REDUCING FOR FLANGING, & IN THE CASE OF STIFFRS 9" DEEP & UPWARDS THE THICKNESSES GIVEN IN THE TABLE FOR FLANGED BKTS SHOULD BE INCREASED 25% TO ARRIVE AT THE BASIC THICKNESS FOR THE SIZE OF THE WELDS. (L.O. 11/10/48)

NOTES.—TABLES 33, 34 & 35.

1. **Length of Stiffeners** is to be measured over the full distance between the top and bottom boundaries of the bulkhead.

2. **Correction for Spacing.**—If the spacing of the stiffeners differs from the Table spacing the modulus is to be modified in direct proportion.

3. **Welded Construction.**—When the bulkhead plating, boundaries, stiffeners and end brackets are welded, the modulus of the stiffeners may, in general, be reduced by 15 per cent, but due consideration is to be given to stiffness and to the rigidity of the structure to which the end brackets are attached.

(109) WITH WELDED CONSTRUCTION THE BRACKETS MAY BE IN ACCORDANCE WITH THE REQUIREMENTS FOR THE EQUIVALENT BULB ANGLE OR CHANNEL STIFFENER AFTER THE REDUCTION FOR WELDING IS MADE.

4. **Riveted End Attachments** are to be in accordance with the requirements of **Table 36.**

5. Particulars of sections and moduli are given in **Table 56.**

TABLE 37 TUNNEL PLATING.

Stiffeners spaced 36 inches apart.

DEPTH. (*See* Note 1)	THICKNESS.		DEPTH. (*See* Note 1)	THICKNESS.	
	FLAT SIDE PLATING.	CURVED TOP PLATING.		FLAT SIDE PLATING.	CURVED TOP PLATING.
Feet.	Inches	Inches.	Feet.	Inches.	Inches.
8	·29	·26	36	·45	·40
12	·31	·28	40	·47	·42
16	·33	·30	44	·49	·44
20	·35	32	48	·51	·46
24	·38	·34	52	·54	·48
28	·40	·36	56	·56	·50
32	·42	·38	60	·58	·52

NOTES.—TABLE 37.

1. **Depth** is to be measured at mid-length of the tunnel from the bulkhead deck at the centre line to the lower edge of the plate.

2. **Correction for Spacing of Stiffeners.**

When the spacing differs from 36 inches the thickness is to be modified at the rate of 2 per cent for every inch of difference.

3. For additions under hatchways *see* **Section 17, clause 2.**

For tunnels in deep tanks *see* **Section 19, clause 4 and Section 20, clause 6.**

TUNNEL STIFFENERS.

TABLE 38

Spaced 36 inches apart.

DEPTH. (*See* Note 1)	LENGTH FROM BASE OF TUNNEL TO TOP OF FLAT SIDE.					
	Feet. 3	Feet. 4	Feet. 5	Feet. 6	Feet. 7	Feet. 8
Feet.	INCHES *Modulus—Inches*^{3}					
12	$3 \times 2\frac{1}{2} \times \cdot 24$ *·80*	$3\frac{1}{2} \times 3 \times \cdot 34$ *1·45*	$4 \times 3 \times \cdot 38$ *2·10*	$5 \times 3 \times \cdot 34$ *2·85*	$5 \times 3 \times \cdot 44$ *3·65*	$5\frac{1}{2} \times 3 \times \cdot 35$ *5·70*
16	$3 \times 2\frac{1}{2} \times \cdot 29$ *·95*	$4 \times 3 \times \cdot 30$ *1·65*	$5 \times 3 \times \cdot 32$ *2·70*	$5 \times 3 \times \cdot 44$ *3·65*	$5\frac{1}{2} \times 3 \times \cdot 35$ *5·70*	$6 \times 3 \times \cdot 35$ *6·95*
20	$3\frac{1}{2} \times 2\frac{1}{2} \times \cdot 26$ *1·15*	$4 \times 3 \times \cdot 38$ *2·10*	$5 \times 3 \times \cdot 42$ *3·50*	$6 \times 3 \times \cdot 38$ *4·55*	$6 \times 3 \times \cdot 35$ *6·95*	$6 \times 3 \times \cdot 45$ *8·35*
24	$4 \times 3 \times \cdot 28$ *1·55*	$5 \times 3 \times \cdot 32$ *2·70*	$6 \times 3 \times \cdot 32$ *3·90*	$5\frac{1}{2} \times 3 \times \cdot 37$ *5·95*	$6 \times 3 \times \cdot 38$ *7·35*	$7 \times 3 \times \cdot 37$ *10·10*
28	$4 \times 3 \times \cdot 30$ *1·65*	$5 \times 3 \times \cdot 36$ *3·00*	$6 \times 3 \times \cdot 40$ *4·75*	$6 \times 3 \times \cdot 35$ *6·95*	$6 \times 3 \times \cdot 48$ *8·75*	$7 \times 3 \times \cdot 48$ *12·05*
32	$4 \times 3 \times \cdot 38$ *2·10*	$5 \times 3 \times \cdot 42$ *3·50*	$5\frac{1}{2} \times 3 \times \cdot 37$ *5·95*	$6 \times 3 \times \cdot 45$ *8·35*	$7 \times 3 \times \cdot 39$ *10·45*	$8 \times 3 \times \cdot 39$ *14·10*
36	$4 \times 3 \times \cdot 40$ *2·20*	$6 \times 3 \times \cdot 32$ *3·90*	$6 \times 3 \times \cdot 35$ *6·95*	$6 \times 3 \times \cdot 48$ *8·75*	$7 \times 3 \times \cdot 47$ *11·85*	$8 \times 3 \times \cdot 42$ *14·75*
40	$4 \times 3 \times \cdot 43$ *2·35*	$6 \times 3 \times \cdot 38$ *4·55*	$6 \times 3 \times \cdot 36$ *7·10*	$7 \times 3 \times \cdot 37$ *10·10*	$8 \times 3 \times \cdot 39$ *14·10*	$8 \times 3\frac{1}{2} \times \cdot 52$ *17·15*
44	$5 \times 3 \times \cdot 32$ *2·70*	$6 \times 3 \times \cdot 40$ *4·75*	$6 \times 3 \times \cdot 45$ *8·35*	$7 \times 3 \times \cdot 48$ *12·05*	$8 \times 3 \times \cdot 42$ *14·75*	$9 \times 3\frac{1}{2} \times \cdot 41$ *19·15*
48	$5 \times 3 \times \cdot 36$ *3·00*	$5\frac{1}{2} \times 3 \times \cdot 35$ *5·70*	$6 \times 3 \times \cdot 47$ *8·60*	$7 \times 3 \times \cdot 49$ *12·25*	$8 \times 3\frac{1}{2} \times \cdot 49$ *16·45*	$9 \times 3\frac{1}{2} \times \cdot 45$ *20·20*
52	$5 \times 3 \times \cdot 42$ *3·50*	$5\frac{1}{2} \times 3 \times \cdot 37$ *5·95*	$7 \times 3 \times \cdot 37$ *10·10*	$8 \times 3 \times \cdot 39$ *14·10*	$9 \times 3\frac{1}{2} \times \cdot 41$ *19·15*	$9 \times 3\frac{1}{2} \times \cdot 52$ *22·20*
56	$5 \times 3 \times \cdot 44$ *3·65*	$6 \times 3 \times \cdot 35$ *6·95*	$7 \times 3 \times \cdot 39$ *10·45*	$8 \times 3 \times \cdot 42$ *14·75*	$9 \times 3\frac{1}{2} \times \cdot 45$ *20·20*	$9 \times 3\frac{1}{2} \times \cdot 60$ *24·45*
60	$6 \times 3 \times \cdot 32$ *3·90*	$6 \times 3 \times \cdot 36$ *7·10*	$7 \times 3 \times \cdot 48$ *12·05*	$8 \times 3\frac{1}{2} \times \cdot 49$ *16·45*	$9 \times 3\frac{1}{2} \times \cdot 51$ *21·90*	$10 \times 3\frac{1}{2} \times \cdot 50$ *27·40*

ANGLES

BULB ANGLES

Section moduli above are given to nearest ·05.

NOTES.—TABLE 38.

1. **Depth** is to be measured at mid-length of the tunnel from the bulkhead deck at the centre line to the base of the tunnel.

2. **Correction for Spacing.**

If the spacing of the stiffeners differs from 36 inches the Table modulus is to be modified in direct proportion.

3. Particulars of sections and moduli are given in Table 56.

(100) EXTRAPOLATION DOWN TO A NUMERAL OF 2 MAY BE MADE.

TABLE 39 — STIFFENERS TO NON

LENGTH OF STIFFENER.		NUMERAL. NOT EXCEEDING 5	10	15	20	30	40
		← SINGLE STIFFENERS. →				← DOUBLE STIFFENERS. →	
Feet.		Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
8	ANGLES	4 × 3 × ·32	5 × 3 × ·36	5½ × 3 × ·34	6 × 3 × ·40	5 × 3 × ·30	5½ × 3 × ·38
10	ANGLES	5 × 3 × ·32	5½ × 3 × ·32	6 × 3 × ·34	7 × 3 × ·36	5½ × 3 × ·30	6 × 3 × ·38
12	ANGLES	5 × 3 × ·36	6 × 3 × ·32	7 × 3 × ·34	8 × 3 × ·36	6 × 3 × ·32	6 × 3 × ·44
14	ANGLES	5 × 3 × ·40	6 × 3 × ·38	7 × 3 × ·40	8 × 3 × ·42	6 × 3 × ·36	7 × 3 × ·42
16	BULB ANGLES	6 × 3 × ·32	7 × 3 × ·36	8 × 3 × ·36	9 × 3½ × ·40	7 × 3 × ·36	8 × 3 × ·42
18	BULB ANGLES	6 × 3 × ·38 A 3·73.	7 × 3 × ·42	8 × 3 × ·42	9 × 3½ × ·46	7 × 3 × ·40	8 × 3 × ·46
20	BULB ANGLES	7 × 3 × ·38 A 4·30.	8 × 3 × ·42	9 × 3½ × ·42	10 × 3½ × ·48	8 × 3 × ·40	9 × 3½ × ·44
22	BULB ANGLES	7 × 3 × ·44	8 × 3 × ·48	9 × 3½ × ·50	10 × 3½ × ·56	8 × 3 × ·44	9 × 3½ × ·50
24	BULB ANGLES	8 × 3 × ·40	9 × 3½ × ·44	10 × 3½ × ·48	11 × 3½ × ·54	9 × 3½ × ·42	10 × 3½ × ·48
26	BULB ANGLES	8 × 3 × ·46	9 × 3½ × ·50	10 × 3½ × ·54	11 × 3½ × ·60	9 × 3½ × ·46	10 × 3½ × ·54
28	BULB ANGLES	9 × 3½ × ·42	10 × 3½ × ·48	11 × 3½ × ·52	12 × 3½ × ·58	10 × 3½ × ·42	11 × 3½ × ·50
30	BULB ANGLES	9 × 3½ × ·48	10 × 3½ × ·54	11 × 3½ × ·56	12 × 3½ × ·62	10 × 3½ × ·46	11 × 3½ × ·56
32	BULB ANGLES	10 × 3½ × ·44	11 × 3½ × ·48	11 × 3½ × ·58	12 × 3½ × ·66	11 × 3½ × ·44	12 × 3½ × ·52

(87) INTERPOLATION ON BASIS OF AREA, FOR WELDED STIFFENERS AREA IS TO BE MAINTAINED, BUT INERTIA MAY BE REDUCED.

NOTES.—TABLE 39.

1. **Length** of stiffener is to be measured between the top and bottom boundaries of the bulkhead.

2. **The Numeral,** whether for stiffeners supporting deck beams, strong hatch end beams or deck transverses, is to be obtained as for pillars; *see* **Table 31, Notes 1 and 2.**

3. **Arrangements with Longitudinally Framed Decks.**—The stiffeners not supporting deck transverses are to have a modulus 25 per cent less than that derived from the column headed "Not exceeding 5". The ends of hold

WATERTIGHT BULKHEADS.

TABLE 39

NUMERAL.					LENGTH OF STIFFENER.
50	60	70	80	90	
DOUBLE STIFFENERS.					
Inches.	Inches.	Inches.	Inches.	Inches.	Feet.
6 × 3 × ·38	6 × 3 × ·42	7 × 3 × ·42	8 × 3 × ·40	8 × 3 × ·46	8
6 × 3 × ·42	7 × 3 × ·42	7 × 3 × ·46	8 × 3 × ·44	8 × 3 × ·50	10
7 × 3 × ·42	8 × 3 × ·42	8 × 3 × ·46	8 × 3 × ·50	9 × 3½ × ·50	12
8 × 3 × ·40	8 × 3 × ·44	9 × 3½ × ·46	9 × 3½ × ·50	10 × 3½ × ·52	14
8 × 3 × ·46	9 × 3½ × ·46	9 × 3½ × ·52	10 × 3½ × ·52	10 × 3½ × ·58	16
9 × 3½ × ·44	9 × 3½ × ·50	10 × 3½ × ·52	10 × 3½ × ·56	11 × 3½ × ·56	18
9 × 3½ × ·50	10 × 3½ × ·50	10 × 3½ × ·58	11 × 3½ × ·56	11 × 3½ × ·60	20
10 × 3½ × ·50	10 × 3½ × ·56	11 × 3½ × ·56	11 × 3½ × ·60	12 × 3½ × ·60	22
10 × 3½ × ·56	11 × 5½ × ·54	12 × 3½ × ·56	12 × 3½ × ·60		24
11 × 3½ × ·54	11 × 3½ × ·60	12 × 3½ × ·60			26
11 × 3½ × ·60	12 × 3½ × ·60				28
12 × 3½ × ·56					30
12 × 3½ × ·60					32

BULB ANGLES.

NOTES.—TABLE 39 (*continued*).

stiffeners are to be lugged or welded to the inner bottom and deck.

4. **Coal Bunker Bulkheads.** — The scantlings of stiffeners for bunker bulkheads, not supporting decks, are to be determined from the column headed "Not exceeding 5" for a spacing of 36 inches, but the modulus may be reduced by 25 per cent.

5. For end connections and constructional details *see* **Section 18.**

TABLE 40 STIFFENERS ON BOUNDARY BULKHEADS OF DEEP TANKS

Y.J with 24" × .60" plating.

Spaced 24 inches apart.

LENGTH OF STIFFENER.	HEAD H FEET. 3	4	5	6	8	10	12	14
Feet.	INCHES *Modulus—Inches³*							
5	3 × 3 × ·26 *·85*	3 × 3 × ·30 *1·00*	3½ × 3 × ·28 *1·20*	3½ × 3 × ·32 *1·40*	4 × 3 × ·34 *1·90*	4 × 3 × ·44 *2·40*	5 × 3 × ·33 *2·80*	5 × 3 × ·39 *3·25*
6	3 × 3 × ·30 *1·00*	3½ × 3 × ·32 *1·40*	4 × 3 × ·31 *1·70*	4 × 3 × ·38 *2·10*	5 × 3 × ·33 *2·80*	5 × 3 × ·41 *3·40*	6 × 3 × ·34 *4·10*	6 × 3 × ·39 *4·65*
7	3½ × 3 × ·32 *1·40*	4 × 3 × ·38 *2·10*	5 × 3 × ·30 *2·55*	5 × 3 × ·34 *2·85*	6 × 3 × ·32 *3·90*	6 × 3 × ·41 *4·85*	5½ × 3 × ·35 *5·70*	6 × 3 × ·32 *6·50*
8	4 × 3 × ·34 *1·90*	5 × 3 × ·30 *2·55*	5 × 3 × ·37 *3·10*	6 × 3 × ·30 *3·70*	6 × 3 × ·42 *5·00*	5½ × 3 × ·40 *6·25*	6 × 3 × ·39 *7·50*	6 × 3 × ·48 *8·75*
9	4 × 3 × ·44 *2·40*	5 × 3 × ·39 *3·25*	6 × 3 × ·33 *4·00*	6 × 3 × ·40 *4·75*	5½ × 3 × ·40 *6·25*	6 × 3 × ·42 *7·90*	6 × 3 × ·52 *9·30*	7 × 3 × ·41 *10·80*
10	5 × 3 × ·34 *2·85*	6 × 3 × ·34 *4·10*	6 × 3 × ·42 *5·00*	5½ × 3 × ·36 *5·80*	6 × 3 × ·42 *7·90*	7 × 3 × ·34 *9·60*	7 × 3 × ·46 *11·65*	8 × 3 × ·36 *3·45*
11	5 × 3 × ·42 *3·55*	6 × 3 × ·42 *5·00*	5½ × 3 × ·34 *5·60*	6 × 3 × ·36 *7·10*	7 × 3 × ·33 *9·45*	7 × 3 × ·45 *11·50*	8 × 3 × ·37 *13·65*	8 × 3 × ·46 *15·65*
12	6 × 3 × ·37 *4·55*	5½ × 3 × ·36 *5·80*	5½ × 3 × ·46 *6·95*	6 × 3 × ·44 *8·20*	7 × 3 × ·42 *10·95*	8 × 3 × ·36 *13·45*	8 × 3 × ·47 *15·90*	9 × 3½ × ·38 *18·40*
13	6 × 3 × ·43 *5·10*	5½ × 3 × ·43 *6·60*	6 × 3 × ·43 *8·05*	7 × 3 × ·34 *9·60*	7 × 3 × ·52 *12·80*	8 × 3 × ·48 *16·10*	9 × 3½ × ·41 *19·15*	9 × 3½ × ·50 *21·60*
14	5½ × 3 × ·34 *5·60*	6 × 3 × ·38 *7·35*	6 × 3 × ·52 *9·30*	7 × 3 × ·44 *11·30*	8 × 3 × ·44 *15·20*	9 × 3½ × ·39 *18·65*	9 × 3½ × ·52 *22·20*	10 × 3½ × ·44 *25·45*
15	6 × 3 × ·34 *6·80*	6 × 3 × ·50 *9·00*	7 × 3 × ·43 *11·15*	8 × 3 × ·36 *13·45*	8 × 3 × ·55 *17·80*	9 × 3½ × ·52 *22·20*	10 × 3½ × ·46 *26·10*	10 × 3½ × ·57 *29·45*
16	6 × 3 × ·42 *7·90*	7 × 3 × ·40 *10·60*	7 × 3 × ·53 *13·00*	8 × 3 × ·44 *15·20*	9 × 3½ × ·47 *20·80*	10 × 3½ × ·43 *25·15*	10 × 3½ × ·56 *29·45*	11 × 3½ × ·48 *33·05*
17	6 × 3 × ·52 9.30 ~~9·15~~	7 × 3 × ·50 *12·40*	8 × 3 × ·44 *15·20*	8 × 3 × ·55 *17·80*	9 × 3½ × ·54 *22·70*	10 × 3½ × ·55 *29·15*	11 × 3½ × ·50 *33·80*	11 × 3½ × ·62 *38·60*
18	7 × 3 × ·39 *10·45*	8 × 3 × ·39 *14·10*	8 × 3 × ·53 *17·35*	9 × 3½ × ·46 *20·50*	10 × 3½ × ·45 *25·80*	11 × 3½ × ·49 *33·45*	12 × 3½ × ·46 *39·45*	12 × 4 × 4 × ·46 *45·40*
19	7 × 3 × ·49 *12·15*	8 × 3 × ·49 *16·35*	9 × 3½ × ·45 *20·20*	9 × 3½ × ·58 *23·85*	10 × 3½ × ·60 *30·80*	11 × 3½ × ·62 *38·60*	12 × 3½ × 3½ × ·54 *45·30*	12 × 4 × 4 × ·61 *51·40*
20	8 × 3 × ·38 *13·85*	9 × 3½ × ·38 *18·40*	9 × 3½ × ·54 *22·70*	10 × 3½ × ·49 *27·10*	11 × 3½ × ·55 *35·8*	12 × 4 × 4 × ·44 *44·60*	12 × 4 × 4 × ·62 *51·80*	*58·70*
21	8 × 3 × ·46 *15·75*	9 × 3½ × ·48 *21·05*	10 × 3½ × ·46 *26·10*	*31·25*	12 × 3½ × ·50 *41·20*	12 × 4 × 4 × ·60 *51·00*	*59·80*	15 × 4 × 4 × ·56 *65·85*
22	8 × 3 × ·55 *17·80*	9 × 3½ × ·58 *23·85*	10 × 3½ × ·56 *29·45*	11 × 3½ × ·54 *35·40*	12 × 4 × 4 × ·49 *46·60*	*57·60*	15 × 4 × 4 × ·52 *67·05*	*76·90*
23	9 × 3½ × ·48 *21·05*	10 × 3½ × ·49 *27·10*	11 × 3½ × ·49 *33·45*	12 × 3½ × ·47 *39·90*	12 × 4 × 4 × ·64 *52·60*	15 × 4 × 4 × ·48 *64·60*	*76·90*	17 × 4 × 4 × ·56 *86·10*
24	10 × 3½ × ·40 *24·20*	10 × 3½ × ·58 *30·10*	11 × 3½ × ·57 *37·40*	12 × 3½ × 3½ × ·52 *44·50*	*59·40*	15 × 4 × 4 × ·60 *71·80*	17 × 4 × 4 × ·56 *86·10*	17 × 4 × 4 × ·74 *99·25*

ANGLES (5 to 13) — BULB ANGLES (14 to 24)

Section moduli above are given to nearest ·05.

NOTES.—TABLE 40.

1. **Length of Stiffeners** on bulkheads is to be measured as follows:—

(*a*) Where horizontal girders are not fitted:

between the top and bottom boundaries.

(*b*) Where horizontal girders are fitted:

(i) between the top boundary and the highest girder.

(ii) between girder and girder,

(iii) between the lowest girder and the bottom boundary.

On tunnels passing through deep tanks and having a curved top, the length of stiffeners is to be measured from the base of the tunnel to the top of the flat side.

2. **Head H** is to be taken as the greater of the two following values:—

(*a*) the distance in feet from the mid-point of length as defined above to the top of the tank.

PEAK TANKS AND OIL FUEL BUNKERS. TABLE 40

Spaced 24 inches apart.

HEAD H FEET. 16	18	20	22	24	26	28	LENGTH OF STIFFENER.
← INCHES *Modulus—Inches³* →							Feet.
5 × 3 × ·44 *3·65*	6 × 3 × ·34 *4·10*	6 × 3 × ·37 *4·40*	6 × 3 × ·40 *4·75*	6 × 3 × ·44 *5·20*	5½ × 3 × ·36 *5·80*	6 × 3 × ·36 *7·10*	5
6 × 3 × ·44 *5·20*	5½ × 3 × ·36 *5·80*	6 × 3 × ·31 *6·40*	6 × 3 × ·36 *7·10*	6 × 3 × ·40 *7·65*	6 × 3 × ·44 *8·20*	6 × 3 × ·48 *8·75*	6
6 × 3 × ·38 *7·35*	6 × 3 × ·44 *8·20*	6 × 3 × ·50 *9·00*	7 × 3 × ·36 *9·95*	7 × 3 × ·40 *10·60*	7 × 3 × ·44 *11·30*	7 × 3 × ·48 *12·05*	7
7 × 3 × ·35 *9·80*	7 × 3 × ·42 *10·95*	7 × 3 × ·48 *12·05*	8 × 3 × ·35 *13·25*	8 × 3 × ·39 *14·10*	8 × 3 × ·43 *15·00*	8 × 3 × ·47 *15·90*	8
7 × 3 × ·49 *12·25*	8 × 3 × ·37 *13·65*	8 × 3 × ·44 *15·20*	8 × 3 × ·49 *16·35*	8 × 3 × ·55 *17·80*	9 × 3½ × ·41 *19·15*	9 × 3½ × ·45 *20·20*	9
8 × 3 × ·44 *15·20*	8 × 3 × ·51 *16·85*	9 × 3½ × ·39 *18·65*	9 × 3½ × ·46 *20·50*	9 × 3½ × ·50 *21·60*	9 × 3½ × ·55 *23·00*	10 × 3½ × ·42 *24·80*	10
8 × 3 × ·54 *17·55*	9 × 3½ × ·42 *19·40*	9 × 3½ × ·50 *21·60*	9 × 3½ × ·54 *22·70*	10 × 3½ × ·41 *24·50*	10 × 3½ × ·48 *26·80*	10 × 3½ × ·54 *28·80*	11
9 × 3½ × ·46 *20·50*	9 × 3½ × ·54 *22·70*	10 × 3½ × ·43 *25·15*	10 × 3½ × ·50 *27·40*	10 × 3½ × ·56 *29·45*	11 × 3½ × ·44 *31·55*	11 × 3½ × ·49 *33·45*	12
10 × 3½ × ·41 *24·50*	10 × 3½ × ·50 *27·40*	10 × 3½ × ·56 *29·45*	11 × 3½ × ·46 *32·30*	11 × 3½ × ·53 *35·00*	11 × 3½ × ·59 *37·40*	12 × 3½ × ·46 *39·45*	13
10 × 3½ × ·52 ·54 *29·80*	11 × 3½ × ·46 *32·30*	11 × 3½ × ·53 *35·00*	11 × 3½ × ·59 *37·40*	12 × 3½ × ·48 *40·30*	12 × 3½ × 3½ × ·48 *43·00*	12 × 3½ × 3½ × ·54 *45·30*	14
11 × 3½ × ·48 *33·05*	11 × 3½ × ·57 *36·60*	12 × 3½ × ·48 *40·30*	12 × 3½ × 3½ × ·48 *43·00*	12 × 4 × 4 × ·50 *47·00*	12 × 4 × 4 × ·62 *51·80*	*53·60*	15
11 × 3½ × ·59 *37·40*	12 × 3½ × ·50 *41·20*	12 × 3½ × 3½ × ·54 *45·30*	12 × 4 × 4 × ·58 *50·20*	*53·70*	*57·60*	15 × 4 × 4 × ·44 *62·15*	16
12 × 3½ × ·54 *43·05*	12 × 4 × 4 × ·52 *47·80*	12 × 4 × 4 × ·64 *52·60*	*57·60*	15 × 4 × 4 × ·44 *62·15*			17
12 × 4 × 4 × ·58 *50·20*	*56·50*	15 × 4 × 4 × ·44 *62·15*					18
58·70	15 × 4 × 4 × ·50 *65·85*	15 × 4 × 4 × ·60 *71·80*					19
15 × 4 × 4 × ·50 *65·85*	15 × 4 × 4 × ·63 *73·60*	17 × 4 × 4 × ·50 *81·60*					20
76·00	17 × 4 × 4 × ·54 *84·60*						21
17 × 4 × 4 × ·58 *87·55*	17 × 4 × 4 × ·70 *96·35*						22
17 × 4 × 4 × ·75 *99·95*							23
							24

BULB ANGLES — CHANNELS

Section moduli above are given to nearest ·05.

SEE 1951 RULES.

NOTES.—TABLE 40 *(continued)*.

(*b*) half the distance in feet from the mid-point of length as defined above to the top of the overflow.

3. **Correction for Spacing.**

Where the spacing of the stiffeners differs from 24 inches, the modulus is to be modified in direct proportion.

4. **Welded Construction.**

When the bulkhead plating, boundaries, stiffeners and end brackets are welded and the stiffeners are not supported by horizontal girders, the modulus of the stiffeners may, in general, be reduced by 15 per cent, but due consideration is to be given to stiffness and to the rigidity of the structure to which the end brackets are attached.

(110) WHERE HORIZONTAL GIRDERS ARE FITTED THE INERTIA MAY BE 90% OF THE RULE FOR RIVETED CONSTRUCTION.

5. **Riveted End Attachments** are to be in accordance with the requirements of **Table 36.**

SEE DECISION (109) (TABLE 36) RE BRACKETS.

6. Particulars of sections and moduli are given in **Table 56.**

TABLE 41 HORIZONTAL GIRDERS IN OIL FUEL BUNKERS.

NUMERAL.	GIRDER		NUMERAL.	GIRDER.		NUMERAL.	GIRDER.	
	WEB PLATE.	FACE AREA.		WEB PLATE.	FACE AREA.		WEB PLATE.	FACE AREA.
	Inches.	Square Inches.		Inches.	Square Inches.		Inches.	Square Inches.
50	12 × ·34	1·3	500	34 × ·42	6·2	950	48 × ·46	9·8
100	16 × ·34	2·1	550	36 × ·42	6·6	1000	48 × ·46	10·7
150	19 × ·34	2·9	600	37 × ·44	7·4	1100	49 × ·46	12·0
200	22 × ·36	3·5	650	39 × ·44	7·7	1200	52 × ·46	12·0
250	24 × ·36	4·0	700	41 × ·46	8·0	1300	54 × ·48	12·0
300	27 × ·36	4·0	750	43 × ·46	8·3	1400	57 × ·50	12·0
350	29 × ·38	4·5	800	45 × ·46	8·5	1500	60 × ·50	12·0
400	31 × ·38	4·9	850	47 × ·46	8·5			
450	33 × ·40	5·1	900	48 × ·46	8·9			

NOTES.—TABLE 41.

1. **Numeral** = $\frac{s^2 \times d \times H}{100}$

where s = length, in feet, between centres of end brackets.

d = depth, in feet, between the centres of the two adjacent spans of stiffeners or frames supported by the girder.

H = the greater of the two following values :—

(*a*) the distance, in feet, from the girder to the top of the tank.

(*b*) half the distance, in feet, from the girder to the top of the overflow.

2. For tanks which exceed 30 feet in length the scantlings and arrangements will be specially considered.

3. The face area of girders derived from the Table may take the form of rolled sections, flanged girder plates or welded face plates, the width of the girder being the extreme width of the web plate.

4. For end connections and constructional details *see* **Section 20, clause 3.**

STRESS = $\frac{N \times 100/35}{I/y}$

= $\frac{100\,N}{35\,I/y}$.

EXPOSED MACHINERY CASINGS ON UPPER OR SUPERSTRUCTURE DECKS.

TABLE 42

Stiffeners spaced 30 inches apart.

LENGTH L	A			B	
	BASIC HEIGHT OF CASINGS.	PLATING	STIFFENERS	PLATING	STIFFENERS
Feet	Feet.	Inches.	INCHES *Modulus—Inches*^{3}	Inches.	INCHES *Modulus—Inches*^{3}
100	6	·26	$3\frac{1}{2}\times2\frac{1}{2}\times\cdot26$ *1·15*	—	—
200	7	·28	$4\times3\times\cdot28$ *1·55*	·26	$3\frac{1}{2}\times2\frac{1}{2}\times\cdot26$ *1·15*
300	8	·32	$4\times3\times\cdot42$ *2·30*	·28	$3\frac{1}{2}\times2\frac{1}{2}\times\cdot30$ *1·30*
400 AND ABOVE	8	·36	$5\times3\times\cdot44$ *3·65*	·30	$4\times3\times\cdot30$ *1·65*

ANGLES

NOTES.—TABLE 42.

1. Col. A is to be used when the ratio of d/D is greater than ·85 in ships having a length of 200 feet and ·75 in ships of 400 feet and above, values for intermediate lengths being found by interpolation and D being measured to the deck on which the casings are situated.

Col. B is to be used when the ratio d/D is less than ·70.

At intermediate draughts the scantlings may be found by interpolation between Cols. A and B.

2. If the spacing of the stiffeners differs from 30 inches the modulus of the stiffeners is to be modified in direct proportion and when the spacing exceeds 30 inches the thickness of the plating is to be increased at the rate of ·01 inch for every 3 inches excess.

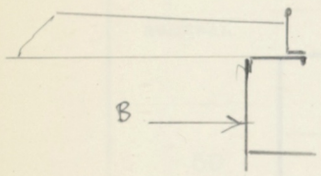
3. Particulars of sections and moduli are given in Table 56.

TABLE 43

(SEE CONTINUATION.)

HATCHWAY BEAMS

A.—RIVETED.



WITH THIS TYPE OF COAMING TAKE B TO INSIDE OF DECK OPENING.

BREADTH OF HATCHWAY.	WEB PLATE. BEAM SPACING CENTRE TO CENTRE.				DOUBLE ANGLES ON EDGES OF BEAMS
	Feet 4	Feet. 5	Feet. 6	Feet. 7	A (one angle)
Feet.	INCHES *Modulus—Inches*^{3}				Inches.
10	*15*	*20*	11 × ·30 *42*	11½×·32 *45*	3 × 3 × ·40 2·24
12	10 × ·38 B.P. *26*	10 × ·44 B.P. *28*	12 × ·32 *48*	13 × ·34 *54*	3 × 3 × ·40 2·24
14	10 × ·46 B.P *29*	12 × ·32 *50*	14 × ·34 *64*	15½×·36 *72*	3 × 3 × ·42 2·34
16	12 × ·32 *54*	14 × ·34 *68*	16 × ·36 *82*	17½×·38 *93*	3½×3 × ·42 2·55
18	14 × ·34 *76*	16 × ·36 *91*	18 × ·36 *107*	19½×·38 *120*	4 × 3 × ·44 2·89
20	15 × ·34 *83*	18 × ·36 *107*	20 × ·38 *124*	22 × ·38 *141*	4 × 3 × ·44 2·89
22	16 × ·36 *100*	19 × ·36 *126*	22 × ·38 *154*	24 × ·40 *170*	4 × 3 × ·50 3·25
24	17 × ·36 *120*	20 × ·38 *150*	23 × ·40 *182*	25½×·42 *210*	5 × 3½×·46 3·70
26	18 × ·36 *142*	21 × ·38 *175*	24 × ·40 *210*	26½×·42 *241*	5 × 3½×·52 4·15
28	19 × ·38 *167*	22 × ·38 *202*	25 × ·40 *240*	28 × ·42 *280*	6 × 3½×·50 4·50
30	20 × ·38 *184*	23 × ·40 *222*	26 × ·42 *261*	29 × ·44 *303*	6 × 3½×·52 4·67

B.—RIVETED.

10	7 × ·36 B.P. *11*	*15*	*17*	*20*	3 × 3 × ·40
12	*15*	*20*	*24*	*32*	3 × 3 × ·40
14	*20*	10 × ·38 B.P. *26*	11 × ·30 *44*	12 × ·32 *50*	3 × 3 × ·42
16	11 × ·30 *48*	11 × ·30 *48*	12 × ·32 *54*	13½×·34 *64*	3½×3 × ·42
18	11 × ·30 *54*	12 × ·32 *61*	14 × ·34 *76*	15½×·36 *87*	4 × 3 × ·44
20	12 × ·32 *61*	13 × ·34 *69*	16 × ·36 *91*	17½×·36 *103*	4 × 3 × ·44
22	12½×·32 *71*	14 × ·34 *83*	17 × ·36 *109*	18½×·38 *123*	4 × 3 × ·50
24	13 × ·34 *84*	14½×·34 *97*	18 × ·36 *128*	19½×·38 *145*	5 × 3½×·46
26	13½×·34 *97*	15 × ·34 *112*	19 × ·38 *154*	20½×·38 *170*	5 × 3½×·52
28	14 × ·34 *112*	16 × ·36 *133*	20 × ·38 *179*	21½×·38 *196*	6 × 3½×·50
30	15 × ·34 *126*	17 × ·36 *149*	21 × ·38 *196*	22½×·38 *214*	6 × 3½×·52

For Notes see page 153.

WHERE HATCH WEB PLATES ARE SCALLOPED, AREA OF FACE PLATE TO BE INCREASED TO MAINTAIN I/y. SCALLOPS SHOULD NOT BE CUT AT THE ENDS OF WEBS (MIN^M OF 6" BETWEEN TOP & BOTTOM SCALLOPS, OR SCALLOP & LIGHTENING HOLE, TO BE MAINTAINED)
J.R.C. 15/12/49. A.U. 21/12/49.

HATCHWAY BEAMS. TABLE 43 (CONCLUDED.)

C.—WELDED.

DEPTH OF BEAM OVER FACE PLATES.	BASIC WEB THICKNESS.	* CORRECTION TO MODULUS PER ·05 INCH VARIATION IN WEB THICKNESS.	BASIC FLANGE THICKNESS.	† CORRECTION TO MODULUS PER ·10 INCH VARIATION IN FLANGE THICKNESS.	AREA OF EACH FACE PLATE. SQUARE INCHES.									
					3	4	5	6	7	8	9	10	11	12
					MODULUS									
Inches.	Inches.	Inches³	Inches.	Inches³	← Inches³ →									
8	·35	·5	·60	1·0	23	30	36							
10	·35	·5	·60	1·0	30	39	48							
12	·40	1·0	·70	1·5		49	60	70						
14	·40	1·5	·70	1·5		60	73	85	98					
16	·45	2·0	·80	2·0			86	101	115	130				
18	·45	2·5	·80	2·0			101	117	133	150	166			
20	·50	3·0	·90	2·5				134	153	171	190	207		
22	·50	3·5	·90	3·0				152	173	193	213	233	254	
24	·55	4·0	1·0	3·5					195	217	239	261	283	305

* When the thickness of the web is increased, the modulus is to be increased by the appropriate correction.
† When the thickness of the flange is increased, the modulus is to be reduced by the appropriate correction.

NOTES.—TABLE 43.

1. **Scantlings** of riveted hatchway beams are to be determined from the Table as follows :—

For hatchways requiring coamings 24 inches in height (**Section 23, clause 1**), in ships 200 feet or more in length ... ... **A**

in ships 100 feet or less in length ... ... **B**

(For intermediate lengths scantlings are to be determined by interpolation.)

For hatchways requiring coamings 18 inches in height, or less, except in cargo spaces ... ... **B**

For hatchways in cargo spaces (*see also* Note 4) ... **A**

For hatchways in accommodation spaces ... ... **B**

2. The Table depth of hatchway beams is to be measured at the mid-length from the top of the upper mounting angles to the bottom of the lower mounting angles or bulb plate. The depth of the ends may be half that at the centre but is not to be less than 6 inches. Alternative arrangements may be adopted if suitable strength is provided at the ends of the webs. The larger flange of the mountings is to be fitted horizontally.

3. Scantlings of welded hatchway beams may be obtained from **C** on the basis of modulus equivalent to the requirements of **A** or **B**. The width of the face plates is to be sufficient to provide the minimum hatch bearing surface required by **Section 23, clause 3** (*d*).

4. Where the 'tween deck height in cargo spaces and trunked hatchways (*see* **Section 23, clause 8**) exceeds 8 feet 6 inches the modulus of the hatchway beams is to be increased in direct proportion.

5. For Construction details *see* **Section 23, clause 3.**

For Riveting *see* **Table 52 (G).**

For Welding *see* **Table 3** of the **Rules for Electric Arc Welding in Ship Construction.**

(67) IF DEPTHS AT ENDS LESS THAN 6", TOP & BOTTOM ANGLE OR FACE PLATE TO BE CARRIED TO EXTREMITY OF WEB.

TANKER = DIA + 10%.

TABLE 44 DIAMETER OF RUDDER HEADS.

NUMERAL.	SEA SPEED IN KNOTS.						
	10 and below	12	14	16	18	20	22
	DIAMETER OF RUDDER HEAD.						
	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
30	$3\frac{1}{2}$	$3\frac{3}{4}$	4	$4\frac{1}{4}$			
40	4	$4\frac{1}{4}$	$4\frac{1}{2}$	$4\frac{3}{4}$			
50	$4\frac{1}{4}$	$4\frac{1}{2}$	$4\frac{3}{4}$	$5\frac{1}{4}$			
60	$4\frac{1}{2}$	$4\frac{3}{4}$	5	$5\frac{1}{2}$			
70	$4\frac{3}{4}$	5	$5\frac{1}{4}$	$5\frac{3}{4}$			
80	5	$5\frac{1}{4}$	$5\frac{1}{2}$	6			
90	$5\frac{1}{4}$	$5\frac{1}{2}$	$5\frac{3}{4}$	$6\frac{1}{4}$	$6\frac{3}{4}$		
100	$5\frac{1}{2}$	$5\frac{3}{4}$	$6\frac{1}{4}$	$6\frac{3}{4}$	$7\frac{1}{4}$		
120	6	$6\frac{1}{4}$	$6\frac{3}{4}$	$7\frac{1}{4}$	$7\frac{3}{4}$		
140	$6\frac{1}{4}$	$6\frac{1}{2}$	7	$7\frac{1}{2}$	8	$8\frac{1}{2}$	
160	$6\frac{3}{4}$	7	$7\frac{1}{2}$	8	$8\frac{1}{2}$	9	
190	$7\frac{1}{4}$	$7\frac{1}{2}$	8	$8\frac{1}{2}$	9	$9\frac{1}{2}$	
220	$7\frac{3}{4}$	8	$8\frac{1}{2}$	9	$9\frac{1}{2}$	10	$10\frac{3}{4}$
260	$8\frac{1}{4}$	$8\frac{1}{2}$	9	$9\frac{1}{2}$	10	$10\frac{1}{2}$	$11\frac{1}{4}$
300	$8\frac{1}{2}$	$8\frac{3}{4}$	$9\frac{1}{4}$	$9\frac{3}{4}$	$10\frac{1}{2}$	11	$11\frac{3}{4}$
350	9	$9\frac{1}{4}$	$9\frac{3}{4}$	$10\frac{1}{4}$	11	$11\frac{1}{2}$	$12\frac{1}{4}$
400	$9\frac{1}{2}$	$9\frac{1}{2}$	$10\frac{1}{4}$	$10\frac{3}{4}$	$11\frac{1}{2}$	12	13
450	10	10	$10\frac{1}{2}$	11	12	$12\frac{1}{2}$	$13\frac{1}{2}$
510	$10\frac{1}{2}$	$10\frac{1}{2}$	11	$11\frac{1}{2}$	$12\frac{1}{2}$	13	14
570	11	11	$11\frac{1}{2}$	12	13	$13\frac{1}{2}$	$14\frac{3}{4}$
640	$11\frac{1}{2}$	$11\frac{1}{2}$	12	$12\frac{1}{2}$	$13\frac{1}{2}$	$14\frac{1}{4}$	$15\frac{1}{2}$
720	12	12	$12\frac{1}{2}$	13	14	15	16
800	$12\frac{1}{2}$	$12\frac{1}{2}$	13	$13\frac{1}{2}$	$14\frac{1}{2}$	$15\frac{1}{2}$	$16\frac{1}{2}$
890	13	13	$13\frac{1}{2}$	14	15	16	17
980	$13\frac{1}{2}$	$13\frac{1}{2}$	14	$14\frac{1}{2}$	$15\frac{1}{2}$	$16\frac{1}{2}$	$17\frac{1}{2}$
1080	14	14	$14\frac{1}{2}$	$15\frac{1}{4}$	$16\frac{1}{4}$	$17\frac{1}{4}$	$18\frac{1}{4}$
1180	$14\frac{1}{2}$	$14\frac{1}{2}$	15	16	17	18	19
1290	15	15	$15\frac{1}{2}$	$16\frac{1}{2}$	$17\frac{1}{2}$	$18\frac{1}{2}$	$19\frac{1}{2}$
1400	$15\frac{1}{2}$	$15\frac{1}{2}$	16	17	18	19	20

NOTES.—TABLE 44.

1. **Numeral.**—(*a*) The numeral = A × D where :

A = total area of rudder in square feet, including balanced portion, if any.

D = distance in feet of centre of gravity of area A from the centre line of the pintles.

(*b*) For balanced rudders the numeral is not to be less than 80 per cent of that derived from the part of the rudder abaft the centre line of the pintles.

2. For rudders strengthened for Navigation in Ice *see* **Section 10, clause 7.**

TABLE 45

SINGLE PLATE RUDDERS.

DIAMETER OF RUDDER HEAD, TABLE 44.	ARMS—SPACED 48 INCHES BETWEEN CENTRES.				PLATE.	DIAMETER OF RIVETS SPACED $4\frac{1}{2}$ DIAMETERS APART CENTRE TO CENTRE.
	BREADTH.	THICKNESS.				
		AT MAINPIECE.	ROUND MAINPIECE.	AT END.		
Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
3	3	2	$1\frac{3}{8}$	$\frac{3}{4}$	·78	$\frac{7}{8}$
4	4	$2\frac{3}{8}$	$1\frac{3}{4}$	$\frac{7}{8}$	·80	1
5	5	$2\frac{3}{4}$	$2\frac{1}{8}$	1	·82	$1\frac{1}{8}$
6	$5\frac{1}{2}$	$3\frac{1}{8}$	$2\frac{1}{4}$	1	·84	$1\frac{1}{8}$
7	6	$3\frac{5}{8}$	$2\frac{1}{2}$	1	·86	$1\frac{1}{8}$
8	$6\frac{1}{2}$	4	$2\frac{3}{4}$	1	·88	$1\frac{1}{4}$
9	7	$4\frac{1}{4}$	3	1	·90	$1\frac{1}{4}$
10	$7\frac{1}{2}$	$4\frac{5}{8}$	$3\frac{1}{4}$	$1\frac{1}{8}$	·92	$1\frac{1}{4}$
11	8	5	$3\frac{1}{2}$	$1\frac{1}{8}$	·94	$1\frac{1}{4}$
12	$8\frac{1}{2}$	$5\frac{3}{8}$	$3\frac{5}{8}$	$1\frac{1}{8}$	·96	$1\frac{1}{4}$
13	$8\frac{3}{4}$	$5\frac{3}{4}$	$3\frac{3}{4}$	$1\frac{1}{8}$	·96	$1\frac{1}{4}$
14	9	6	$3\frac{7}{8}$	$1\frac{1}{8}$	·98	$1\frac{1}{4}$
15	$9\frac{1}{4}$	$6\frac{1}{4}$	4	$1\frac{1}{8}$	·98	$1\frac{1}{4}$

NOTES.—TABLE 45.

Corrections for Spacing of Arms.—The breadth of the arms is to be modified directly as the spacing.

The thickness of the plate is to be modified with the spacing at the rate of ·01 inch for every inch increase or reduction from 48 inches.

TABLE 46

DOUBLE PLATE RUDDERS.

SIDE PLATES.

DIAMETER OF RUDDER HEAD TABLE 44.	SPACING OF ARMS BETWEEN CENTRES. INCHES. FORGED & CAST FRAMES. 36	48	60	SOLID FRAMES. DIAMETER OF RIVETS SPACED $4\frac{1}{2}$ DIAMETERS APART CENTRE TO CENTRE.
	PLATE FRAMES. 24	36	48	
Inches.	Inches.	Inches.	Inches.	Inches.
4	·32	·40		$\frac{3}{4}$
5	·34	·40		$\frac{3}{4}$
6	·36	·42	·48	$\frac{7}{8}$
7	·36	·44	·50	$\frac{7}{8}$
8	·38	·46	·52	$\frac{7}{8}$
9	·38	·46	·54	$\frac{7}{8}$
10	·40	·48	·56	1
11	·40	·48	·58	1
12	·42	·50	·60	1
13	·42	·50	·60	1
14	·44	·52	·62	1
15	·44	·52	·62	1

NOTES.—TABLE 46.

1. **Plate Thickness.**—When the ratio of the fore and aft dimension to the vertical dimension of the unsupported panels of plating exceeds 3:2 an additional vertical diaphragm is to be fitted.

The thickness of side plates of rudder with a plate frame may require to be increased in way of the vertical webs which replace the mainpiece.

2. **Plate Frames.**—Horizontal webs and vertical webs not replacing the mainpiece are to have the same thickness as the side plates, but the plates forming the top and bottom of the rudder are to be of increased thickness.

Vertical webs replacing the mainpiece are to have a thickness equal to twice the Table thickness of side plates for 36 inches spacing.

RUDDER PINTLES. TABLE 47

ONE OR TWO PINTLES.

BALANCED OR UNBALANCED RUDDERS.

AREA SUPPORTED (*See* Note 1)	SEA SPEED IN KNOTS.					
	12 and below	14	16	18	20	22
	DIAMETER OF PINTLES.					
Square Feet.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
10	3·0	3·4	3·8			
20	4·2	4·7	5·2			
40	6·0	6·2	6·6	7·4	8·2	
60	7·4	7·4	7·8	8·6	9·6	
80	8·0	8·0	8·4	9·2	10·4	11·8
100		8·6	9·0	9·8	11·0	12·8
120		9·2	9·6	10·6	12·0	13·8
140		9·8	10·2	11·4	12·8	14·8
160			11·0	12·2	13·6	15·8
180			11·8	13·0	14·8	17·0
200			12·6	13·8	15·8	18·0

THREE OR MORE PINTLES.

UNBALANCED RUDDERS.

AREA SUPPORTED (*See* Note 1)	SEA SPEED IN KNOTS.				
	12 and below	14	16	18	20
	DIAMETER OF PINTLES.				
Square Feet.	Inches.	Inches.	Inches.	Inches	Inches.
10	2·4	2·8	3·2		
20	3·8	4·2	4·6		
30	5·0	5·4	5·8		
40	6·0	6·2	6·6	7·4	
50	6·8	6·9	7·2	8·0	
60	7·4	7·4	7·8	8·6	9·6

NOTES.—TABLE 47.

1. **Area Supported.**—When there is one pintle only the area supported is that below a horizontal line half way between the pintle and the top of the rudder.

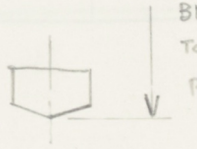
Where there are two pintles the areas supported are those bounded by a horizontal line midway between the two pintles.

Where there are more than two pintles the area supported is to be taken as the total area of the rudder divided by the number of pintles.

IN NORMAL RUDDERS TAKE PINTLES AS EACH SUPPORTING ½ AREA.

2. **Pintles.**—The diameter of pintles obtained from the Table is to be measured outside the liner, if fitted.

The bearing length, except that of the bottom pintle, is to be 20 per cent greater than the diameter. The bearing length of the bottom pintle is to be equal to the diameter of the pintle.



BEARING LENGTH TAKEN TO BOTTOM OF PINTLE.

The length of pintle housing in the rudder gudgeons is to be 20 per cent greater than the diameter of the pintle.

Pintles are to be fitted as taper bolts, the taper not being greater than 1 in 12 on the radius.

MIN^M SPACING OF BOLTS (OLD RULES) 2d CR TO CR.

TABLE 48 COUPLINGS OF RUDDER HEADS.

DIAMETER OF RUDDER HEAD TABLE 44.	HORIZONTAL COUPLING. 6 BOLTS.		VERTICAL COUPLING. 8 BOLTS.		SCARPHED COUPLING.					
						WIDTH OF SCARPHS.		BOLTS.		
								NUMBER.		
	MEAN DISTANCE OF CENTRES OF BOLTS FROM CENTRE OF COUPLING.	DIAMETER OF BOLTS AND THICKNESS OF FLANGES.	WIDTH OF COUPLING.	DIAMETER OF BOLTS AND THICKNESS OF FLANGES.	LENGTH OF SCARPH.	AT TOP.	AT BOTTOM.	TOTAL.	IN TOP ROW.	DIAMETER.
Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.			Inches.
$3\frac{1}{2}$	4	$1\frac{1}{8}$								
$3\frac{3}{4}$	4	$1\frac{1}{8}$								
4	$4\frac{1}{4}$	$1\frac{1}{4}$								
$4\frac{1}{4}$	$4\frac{1}{4}$	$1\frac{1}{4}$								
$4\frac{1}{2}$	$4\frac{1}{2}$	$1\frac{3}{8}$	12	$1\frac{3}{8}$	$13\frac{1}{2}$	9	15	6	2	$1\frac{1}{2}$
$4\frac{3}{4}$	$4\frac{1}{2}$	$1\frac{3}{8}$	12	$1\frac{3}{8}$	$13\frac{1}{2}$	9	15	6	2	$1\frac{1}{2}$
5	$4\frac{1}{2}$	$1\frac{3}{8}$	12	$1\frac{3}{8}$	$13\frac{1}{2}$	9	15	6	2	$1\frac{1}{2}$
$5\frac{1}{4}$	$4\frac{3}{4}$	$1\frac{1}{2}$	12	$1\frac{1}{2}$	$13\frac{1}{2}$	9	15	6	2	$1\frac{1}{2}$
$5\frac{1}{2}$	5	$1\frac{1}{2}$	$12\frac{1}{2}$	$1\frac{1}{2}$	14	$9\frac{1}{2}$	$15\frac{1}{2}$	6	2	$1\frac{5}{8}$
$5\frac{3}{4}$	$5\frac{1}{4}$	$1\frac{1}{2}$	13	$1\frac{1}{2}$	$14\frac{1}{2}$	10	16	6	2	$1\frac{3}{4}$
6	$5\frac{1}{2}$	$1\frac{5}{8}$	$13\frac{1}{2}$	$1\frac{5}{8}$	15	$10\frac{1}{2}$	$16\frac{1}{2}$	6	2	$1\frac{7}{8}$
$6\frac{1}{4}$	$5\frac{3}{4}$	$1\frac{3}{4}$	14	$1\frac{3}{4}$	$15\frac{3}{4}$	11	$17\frac{1}{4}$	6	2	2
$6\frac{1}{2}$	6	$1\frac{7}{8}$	$14\frac{1}{2}$	$1\frac{7}{8}$	$16\frac{1}{4}$	$11\frac{1}{2}$	18	6	2	$2\frac{1}{8}$
$6\frac{3}{4}$	$6\frac{1}{4}$	$1\frac{7}{8}$	15	$1\frac{7}{8}$	17	12	$18\frac{3}{4}$	6	2	$2\frac{1}{8}$
7	$6\frac{1}{2}$	2	$15\frac{3}{4}$	2	$17\frac{1}{2}$	$12\frac{1}{4}$	$19\frac{1}{2}$	6	2	$2\frac{1}{4}$
$7\frac{1}{4}$	$6\frac{3}{4}$	$2\frac{1}{8}$	$16\frac{1}{4}$	$2\frac{1}{8}$	18	$12\frac{3}{4}$	20	6	2	$2\frac{1}{4}$
$7\frac{1}{2}$	7	$2\frac{1}{8}$	$16\frac{3}{4}$	$2\frac{1}{8}$	$18\frac{3}{4}$	$13\frac{1}{4}$	21	7	2	$2\frac{1}{8}$
$7\frac{3}{4}$	$7\frac{1}{4}$	$2\frac{1}{4}$	$17\frac{1}{4}$	$2\frac{1}{4}$	$19\frac{1}{2}$	$13\frac{1}{2}$	$21\frac{1}{2}$	7	2	$2\frac{1}{8}$
8	$7\frac{1}{2}$	$2\frac{3}{8}$	18	$2\frac{3}{8}$	20	14	22	7	2	$2\frac{1}{4}$
$8\frac{1}{2}$	$7\frac{3}{4}$	$2\frac{1}{2}$	19	$2\frac{1}{2}$	$21\frac{1}{4}$	15	24	7	2	$2\frac{1}{2}$
9	$8\frac{1}{4}$	$2\frac{3}{4}$	20	$2\frac{3}{4}$	$22\frac{1}{2}$	$15\frac{3}{4}$	25	7	2	$2\frac{5}{8}$
$9\frac{1}{2}$	$8\frac{1}{2}$	$2\frac{7}{8}$	$21\frac{1}{4}$	$2\frac{7}{8}$	$23\frac{3}{4}$	$16\frac{3}{4}$	26	7	2	$2\frac{3}{4}$
10	9	3	$22\frac{1}{2}$	3	25	$17\frac{1}{2}$	$27\frac{1}{2}$	7	2	$2\frac{7}{8}$
$10\frac{1}{2}$	$9\frac{1}{2}$	$3\frac{1}{8}$	$23\frac{1}{2}$	$3\frac{1}{8}$	$26\frac{1}{4}$	$18\frac{1}{2}$	29	8	2	$2\frac{7}{8}$
11	10	$3\frac{1}{4}$	$24\frac{3}{4}$	$3\frac{1}{4}$	$27\frac{1}{2}$	$19\frac{1}{4}$	30	8	2	3
$11\frac{1}{2}$	$10\frac{1}{2}$	$3\frac{3}{8}$	26	$3\frac{3}{8}$	$28\frac{3}{4}$	$20\frac{1}{4}$	$31\frac{1}{2}$	8	2	$3\frac{1}{8}$
12	$10\frac{3}{4}$	$3\frac{1}{2}$	27	$3\frac{1}{2}$	30	21	33	8	2	$3\frac{1}{4}$
$12\frac{1}{2}$	$11\frac{1}{4}$	$3\frac{5}{8}$	28	$3\frac{5}{8}$	$31\frac{1}{4}$	25	$34\frac{1}{2}$	9	3	$3\frac{1}{4}$
13	$11\frac{3}{4}$	$3\frac{3}{4}$	29	$3\frac{3}{4}$	$32\frac{1}{2}$	26	36	9	3	$3\frac{1}{4}$
$13\frac{1}{2}$	$12\frac{1}{4}$	$3\frac{7}{8}$	30	$3\frac{7}{8}$	$33\frac{3}{4}$	27	$37\frac{1}{2}$	9	3	$3\frac{3}{8}$
14	$12\frac{3}{4}$	4	$31\frac{1}{2}$	4	35	28	39	9	3	$3\frac{5}{8}$
$14\frac{1}{2}$	13	$4\frac{1}{8}$	$32\frac{1}{2}$	$4\frac{1}{8}$	$36\frac{1}{4}$	29	40	9	3	$3\frac{3}{4}$
15	$13\frac{1}{2}$	$4\frac{1}{4}$	$33\frac{1}{2}$	$4\frac{1}{4}$	$37\frac{1}{2}$	30	41	9	3	$3\frac{7}{8}$

NOTES.—TABLE 48.

1. The width of material in the flanges, or palms of scarphs, outside the bolt holes is not to be less than two thirds of the diameter of the bolt.

CR. OF BOLTS NOT LESS THAN 7/6 DIA (1·167 DIA) FROM OUTSIDE OF COUPLING, i.e. OVERALL DIAM. OF COUPLING WITH RULE CENTRES

2. In scarphed couplings the athwartship dimension at the top of the scarph is not to be less than the diameter of the rudder head. The thickness of the tips of the palms is not to be less than thirteen per cent of the diameter of the rudder head.

$= (2 \times \text{MEAN DISTANCE}) + \frac{7}{3} \times \text{DIA OF BOLT.}$

STEERING CHAINS, RODS, QUADRANTS AND TILLERS. TABLE 49

DIAMETER OF RUDDER HEAD TABLE 44.	DIAMETER OF WROUGHT IRON CHAINS.	DIAMETER OF RODS.	RADIUS OF QUADRANT.	BOSS OF QUADRANT.		QUADRANTS AND TILLERS.		
						Sizes of Arms at Twice the Diameter of Rudder Head from Centre of Rudder Head.		
				Depth.	Outside Diameter.	One Arm.	Two Arms.	Three Arms.
Inches.	Inches.	Inches.	Feet. Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
$3\frac{1}{2}$	$\frac{9}{16}$	$\frac{5}{8}$	3 — 2	$3\frac{1}{2}$	$6\frac{1}{4}$	$3\frac{1}{2} \times 2\frac{1}{2}$		
$3\frac{3}{4}$	$\frac{9}{16}$	$\frac{5}{8}$	3 — 3	$3\frac{3}{4}$	$6\frac{3}{4}$	$4 \times 2\frac{1}{2}$		
4	$\frac{5}{8}$	$\frac{11}{16}$	3 — 4	4	$7\frac{1}{4}$	$4\frac{1}{4} \times 2\frac{1}{2}$		
$4\frac{1}{4}$	$\frac{11}{16}$	$\frac{3}{4}$	3 — 5	$4\frac{1}{4}$	$7\frac{1}{2}$	$4\frac{1}{2} \times 2\frac{3}{4}$		
$4\frac{1}{2}$	$\frac{11}{16}$	$\frac{3}{4}$	3 — 6	$4\frac{1}{2}$	8	$5 \times 2\frac{3}{4}$	$3\frac{3}{4} \times 2\frac{1}{4}$	
$4\frac{3}{4}$	$\frac{3}{4}$	$\frac{13}{16}$	3 — 7	$4\frac{3}{4}$	$8\frac{1}{2}$	$5\frac{1}{4} \times 2\frac{3}{4}$	$4 \times 2\frac{1}{4}$	
5	$\frac{3}{4}$	$\frac{13}{16}$	3 — 8	5	9	$5\frac{1}{2} \times 3$	$4\frac{1}{4} \times 2\frac{1}{2}$	
$5\frac{1}{4}$	$\frac{13}{16}$	$\frac{7}{8}$	3 — 9	$5\frac{1}{4}$	$9\frac{1}{4}$	$5\frac{3}{4} \times 3$	$4\frac{1}{2} \times 2\frac{1}{2}$	
$5\frac{1}{2}$	$\frac{13}{16}$	$\frac{15}{16}$	3 — 10	$5\frac{1}{2}$	$9\frac{3}{4}$	$6 \times 3\frac{1}{4}$	$4\frac{3}{4} \times 2\frac{1}{2}$	
$5\frac{3}{4}$	$\frac{7}{8}$	$\frac{15}{16}$	3 — 11	$5\frac{3}{4}$	$10\frac{1}{4}$	$6\frac{1}{4} \times 3\frac{1}{4}$	$5 \times 2\frac{1}{2}$	
6	$\frac{7}{8}$	1	4 — 0	6	$10\frac{3}{4}$	$6\frac{1}{2} \times 3\frac{1}{2}$	$5\frac{1}{4} \times 2\frac{3}{4}$	
$6\frac{1}{4}$	$\frac{15}{16}$	$1\frac{1}{16}$	4 — 1	$6\frac{1}{4}$	$11\frac{1}{4}$	$6\frac{3}{4} \times 3\frac{1}{2}$	$5\frac{1}{2} \times 2\frac{3}{4}$	
$6\frac{1}{2}$	$\frac{15}{16}$	$1\frac{1}{16}$	4 — 2	$6\frac{1}{2}$	$11\frac{3}{4}$	$7 \times 3\frac{3}{4}$	$5\frac{1}{2} \times 3$	
$6\frac{3}{4}$	1	$1\frac{1}{8}$	4 — 3	$6\frac{3}{4}$	12	$7\frac{1}{4} \times 3\frac{3}{4}$	$5\frac{3}{4} \times 3$	
7	1	$1\frac{1}{4}$	4 — 4	7	$12\frac{1}{2}$	$7\frac{1}{2} \times 4$	$6 \times 3\frac{1}{4}$	
$7\frac{1}{4}$	$1\frac{1}{16}$	$1\frac{1}{4}$	4 — 5	$7\frac{1}{4}$	13	$7\frac{3}{4} \times 4\frac{1}{4}$	$6 \times 3\frac{1}{4}$	
$7\frac{1}{2}$	$1\frac{1}{16}$	$1\frac{5}{16}$	4 — 6	$7\frac{1}{2}$	$13\frac{1}{2}$	$8 \times 4\frac{1}{2}$	$6\frac{1}{4} \times 3\frac{1}{2}$	
$7\frac{3}{4}$	$1\frac{1}{8}$	$1\frac{3}{8}$	4 — 7	$7\frac{3}{4}$	14	$8\frac{1}{4} \times 4\frac{1}{2}$	$6\frac{1}{4} \times 3\frac{3}{4}$	
8	$1\frac{3}{16}$	$1\frac{3}{8}$	4 — 8	8	$14\frac{1}{2}$	$8\frac{1}{2} \times 4\frac{3}{4}$	$6\frac{1}{2} \times 4$	$5\frac{3}{4} \times 3\frac{1}{2}$
$8\frac{1}{2}$	$1\frac{1}{4}$	$1\frac{1}{2}$	5 — 0	$8\frac{1}{2}$	$15\frac{1}{4}$	9×5	7×4	$6 \times 3\frac{3}{4}$
9	$1\frac{5}{16}$	$1\frac{9}{16}$	5 — 4	9	$16\frac{1}{4}$	$9\frac{1}{2} \times 5\frac{1}{4}$	$7\frac{1}{2} \times 4\frac{1}{4}$	$6\frac{1}{2} \times 3\frac{3}{4}$
$9\frac{1}{2}$	$1\frac{3}{8}$	$1\frac{11}{16}$	5 — 8	$9\frac{1}{2}$	17	$10 \times 5\frac{3}{4}$	$8 \times 4\frac{1}{2}$	7×4
10	$1\frac{7}{16}$	$1\frac{3}{4}$	6 — 0	10	18	$10\frac{1}{2} \times 6$	$8\frac{1}{2} \times 4\frac{1}{2}$	$7\frac{1}{2} \times 4$
$10\frac{1}{2}$	$1\frac{1}{2}$	$1\frac{7}{8}$	6 — 4	$10\frac{1}{2}$	19	$11 \times 6\frac{1}{4}$	$9 \times 4\frac{3}{4}$	8×4
11	$1\frac{9}{16}$	$1\frac{15}{16}$	6 — 8	11	$19\frac{3}{4}$	$11\frac{1}{2} \times 6\frac{3}{4}$	$9\frac{1}{2} \times 5$	$8\frac{1}{2} \times 4\frac{1}{2}$
$11\frac{1}{2}$	$1\frac{5}{8}$	$1\frac{15}{16}$	7 — 0	$11\frac{1}{2}$	$20\frac{3}{4}$	12×7	$10 \times 5\frac{1}{4}$	$8\frac{1}{2} \times 5$
12	$1\frac{5}{8}$	2	7 — 4	12	$21\frac{1}{2}$	$12\frac{1}{2} \times 7\frac{1}{2}$	$10\frac{1}{2} \times 5\frac{1}{2}$	9×5
$12\frac{1}{2}$			7 — 8	$12\frac{1}{2}$	$22\frac{1}{2}$	$13 \times 7\frac{1}{2}$	$11 \times 5\frac{1}{2}$	$9\frac{1}{2} \times 5$
13			8 — 0	13	$23\frac{1}{2}$	$13\frac{1}{2} \times 7\frac{1}{2}$	$11\frac{1}{4} \times 5\frac{3}{4}$	10×5
$13\frac{1}{2}$			8 — 0	$13\frac{1}{2}$	$24\frac{1}{2}$	14×8	$11\frac{1}{2} \times 6$	$10 \times 5\frac{1}{4}$
14			8 — 0	14	$25\frac{1}{4}$	$14\frac{1}{2} \times 8$	12×6	$10\frac{1}{2} \times 5\frac{1}{4}$
$14\frac{1}{2}$			8 — 0	$14\frac{1}{2}$	$26\frac{1}{4}$	$15 \times 8\frac{1}{2}$	$12\frac{1}{4} \times 6\frac{1}{2}$	$10\frac{1}{2} \times 5\frac{1}{2}$
15			8 — 0	15	27	$15\frac{1}{2} \times 8\frac{1}{2}$	$12\frac{3}{4} \times 6\frac{1}{2}$	$11 \times 5\frac{1}{2}$

TABLE 50 BOLTS FOR BOLTED TILLERS AND QUADRANTS.

DIAMETER OF RUDDER HEAD TABLE 44.	ONE BOLT EACH SIDE.		TWO BOLTS EACH SIDE.		FOUR BOLTS EACH SIDE.			THICKNESS OF COUPLING.
	Diameter.	Distance Centre to Centre.	Diameter.	Distance Centre to Centre.	Diameter.	Inner Bolts Centre to Centre.	Outer Bolts Centre to Centre.	
Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
3½	1½	11	1¼	10	¾	8½	13½	1⅜
4	1¾	12	1⅜	11	⅞	9½	15	1½
4½	2	13	1½	12	1	10½	16½	1⅝
5	2¼	14	1¾	13	1⅛	11½	18	1¾
5½	2½	15	1⅞	14	1¼	12½	20	1⅞
6	2¾	16½	2	15	1⅜	13½	22	2
6½	3	18	2⅛	16	1½	15	24	2
7	3¼	19	2¼	17	1⅝	16	25½	2¼
7½	3½	20½	2½	18½	1¾	17	27½	2¼
8	3¾	22	2⅝	20	1⅞	18½	29½	2½
8½	3⅞	23	2¾	21	2	19½	31½	2½
9	4	24	2⅞	22	2⅛	20½	33½	2¾
9½			3	23½	2⅛	21½	34½	2¾
10			3¼	24½	2¼	22½	36	3
10½			3⅜	26	2⅜	24	38	3
11			3⅝	27	2½	25	40	3
11½			3¾	28½	2⅝	26	42	3
12			3⅞	29½	2¾	27	43½	3¼
13			4¼	32	3	29½	47½	3¼
14			4½	34½	3⅛	32	51	3¼
15			4⅞	37	3⅜	34	54	3¼

MASTS AND DERRICK POSTS. TABLE 51

DIAMETER AND THICKNESS AT DECK.

STAYED.

LENGTH OF MAST OR POST.	NO DERRICKS.	WORKING LOAD OF DERRICKS.	
		4 TONS.	8 TONS
Feet.	Inches	Inches.	Inches.
30	12 × ·24	18 × ·30	20 × ·30
35	14 × ·26	20 × ·30	22 × ·32
40	16 × ·28	22 × ·30	24 × ·34
45	18 × ·30	23 × ·32	25 × ·36
50	20 × ·32	24 × ·34	26 × ·38
55	22 × ·34	26 × ·38	28 × ·40
60	24 × ·36	28 × ·40	30 × ·42

UNSTAYED.

LENGTH OF MAST OR POST.	WORKING LOAD OF DERRICKS.	
	4 TONS.	8 TONS.
Feet.	Inches.	Inches.
20	24 × ·36	24 × ·60
25	26 × ·38	26 × ·66
30	28 × ·40	28 × ·72
35	30 × ·40	30 × ·72

NOTES.—TABLE 51.

1. **Length** of mast or derrick post is to be measured from deck to hounds. Tops of small mast houses and derrick plates are not to be regarded as the deck for this purpose, unless the structure is adequately strengthened.

2. **Working Load** of derricks is defined in **Section 28, clause 1**(*a*).

3. The diameter and thickness of masts and derrick posts at the hounds are to be 85 per cent of the scantlings at the deck.

TABLE 52

(SEE CONTINUATION.)

RIVETING.

A.

DIAMETER AND SPACING OF RIVETS AND BREADTHS OF END LAPS, BUTT STRAPS AND SEAMS.

THICKNESS OF PLATES:—	Inches. Not exceeding ·36	Inches. Above ·36 and not exceeding ·50	Inches. Above ·50 and not exceeding ·72	Inches. Above ·72 and not exceeding ·94	Inches. Above ·94 and not exceeding 1·14	Inches. Above 1·14 and not exceeding 1·26
DIAMETER OF RIVETS:—	$\frac{5}{8}$	$\frac{3}{4}$	$\frac{7}{8}$	1	$1\frac{1}{8}$	$1\frac{1}{4}$
SPACING IN DIAMETERS.	SPACING IN INCHES.					
$3\frac{1}{2}$	$2\frac{1}{4}$	$2\frac{5}{8}$	$3\frac{1}{8}$	$3\frac{1}{2}$	4	$4\frac{3}{8}$
4	$2\frac{1}{2}$	3	$3\frac{1}{2}$	4	$4\frac{1}{2}$	5
$4\frac{1}{2}$	$2\frac{3}{4}$	$3\frac{3}{8}$	4	$4\frac{1}{2}$	5	$5\frac{5}{8}$
5	$3\frac{1}{8}$	$3\frac{3}{4}$	$4\frac{3}{8}$	5	$5\frac{5}{8}$	$6\frac{1}{4}$
$5\frac{1}{2}$	$3\frac{1}{2}$	$4\frac{1}{8}$	$4\frac{7}{8}$	$5\frac{1}{2}$	$6\frac{1}{8}$	—
6	$3\frac{3}{4}$	$4\frac{1}{2}$	$5\frac{1}{4}$	6	$6\frac{3}{4}$	—
$6\frac{1}{2}$	4	$4\frac{7}{8}$	$5\frac{3}{4}$	$6\frac{1}{2}$	—	—
7	$4\frac{1}{2}$	$5\frac{1}{4}$	$6\frac{1}{8}$	7	—	—

BREADTHS OF END LAPS, BUTT STRAPS AND SEAMS.

		Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
END LAPS	Single Riveted ...	$2\frac{1}{2}$	3	—	—	—	—
	Double Riveted ...	$4\frac{1}{4}$	5	6	—	—	—
	Treble Riveted ...	6	$7\frac{1}{2}$	9	$10\frac{1}{2}$	12	$13\frac{1}{2}$
	Quadruple Riveted ...	—	—	12	14	16	18
	Quintuple Riveted ...	—	—	15	$17\frac{1}{2}$	20	$22\frac{1}{2}$
BUTT STRAPS*	Single Riveted ...	$4\frac{1}{2}$	$5\frac{1}{4}$	—	—	—	—
	Double Riveted ...	8	$9\frac{3}{4}$	$11\frac{1}{4}$	—	—	—
	Treble Riveted ...	—	$14\frac{1}{4}$	$16\frac{3}{4}$	19	$21\frac{1}{2}$	24
	Quadruple Riveted ...	—	—	22	25	$28\frac{1}{4}$	$31\frac{1}{2}$
SEAMS	Single Riveted ...	$2\frac{1}{4}$	$2\frac{1}{2}$	3	$3\frac{1}{2}$	—	—
	Double Riveted ...	$3\frac{3}{4}$	$4\frac{1}{2}$	$5\frac{1}{4}$	6	$6\frac{3}{4}$	$7\frac{1}{2}$
	Treble Riveted ...	—	—	—	$8\frac{1}{2}$	$9\frac{1}{2}$	$10\frac{1}{2}$

*Single butt straps are to be 25 per cent thicker than the plates to be connected. Where double butt straps are fitted the thickness of the countersunk strap is to be 70 per cent and thickness of the strap on the opposite side is to be 60 per cent of the thickness of the plates to be connected.

NOTES.—TABLE 52 (A).

1. The diameter of rivets in seams of keel, sheerstrake, deck stringer, middle line strake of inner bottom and margin plate is to be regulated by the thickness of the adjacent plating.

2. Rivets are to be kept sufficiently clear of edges of plating and of each other, and the distance from the centre of rivet holes to the edges of the plating, end laps or butt straps is not to be less than one and a half rivet diameters.

3. The distance between the centres of consecutive rows of rivets is to be three and a half diameters in end laps, three diameters in butt straps and two and a half diameters in seams.

RIVETING.

B.

END LAPS AND SEAMS OF SHELL PLATING.

TABLE 52
(SEE CONTINUATION.)

ITEM.	THICKNESS.		END LAPS AND BUTT STRAPS.					SEAMS.	
	Above.	Not exceeding.	Diameter of Rivets.	Type of End Lap and Single Butt Strap.	Breadth. End Laps.	Breadth. Butt Strap.	Spacing of Rivets. Centre to Centre.	Type of Seam.	Breadth.
	Inches.	Inches.	Inches.		Inches.	Inches.	Inches		Inches.
Sheerstrake for ·4L amidships. (108) SEE NOTE 4 Bottom Plating from keel to upper turn of bilge for ·4L amidships. Keel Plates. SEE NOTE 4 (108) Boss Plates.		·36	$\frac{5}{8}$	Double	$4\frac{1}{4}$	8	$2\frac{1}{4}$	Single	$2\frac{1}{4}$
	·36	·42	$\frac{3}{4}$	Double	5	$9\frac{3}{4}$	3	Double	$4\frac{1}{2}$
	·42	·50	$\frac{3}{4}$	Treble	$7\frac{1}{2}$	$14\frac{1}{4}$	3	Double	$4\frac{1}{2}$
	·50	·68	$\frac{7}{8}$	Treble	9	$16\frac{3}{4}$	$3\frac{1}{2}$	Double	$5\frac{1}{4}$
	·68	·72	$\frac{7}{8}$	Quadruple	12	22	$3\frac{1}{2}$	Double	$5\frac{1}{4}$
	·72	·84	1	Quadruple	14	25	4	Double	6
	·84	·94	1	Quintuple	$17\frac{1}{2}$		$4\frac{1}{2}$	Double	6
	·94	1·14	$1\frac{1}{8}$	Quintuple	20		5	Double	$6\frac{3}{4}$
	1·14	1·26	$1\frac{1}{4}$	Quintuple	$22\frac{1}{2}$		$5\frac{5}{8}$		
Sheerstrake at ends. Bottom Plating from keel to upper turn of bilge at ends.		·36	$\frac{5}{8}$	Double	$4\frac{1}{4}$	8	$2\frac{1}{4}$	Single	$2\frac{1}{4}$
	·36	·42	$\frac{3}{4}$	Double	5	$9\frac{3}{4}$	3	Double	$4\frac{1}{2}$
	·42	·50	$\frac{3}{4}$	Treble	$7\frac{1}{2}$	$14\frac{1}{4}$	3	Double	$4\frac{1}{2}$
	·50	·68	$\frac{7}{8}$	Treble	9	$16\frac{3}{4}$	$3\frac{1}{2}$	Double	$5\frac{1}{4}$
	·68	·72	$\frac{7}{8}$	Quadruple	12	22	$3\frac{1}{2}$	Double	$5\frac{1}{4}$
	·72	·94	1	Quadruple	14	25	4	Double	6
Side Plating from upper turn of bilge to sheerstrake.		·36	$\frac{5}{8}$	Double	$4\frac{1}{4}$	8	$2\frac{1}{4}$	Single	$2\frac{1}{4}$
	·36	·42	$\frac{3}{4}$	Double	5	$9\frac{3}{4}$	3	Single	$2\frac{1}{2}$
	·42	·50	$\frac{3}{4}$	Treble	$7\frac{1}{2}$	$14\frac{1}{4}$	3	Double	$4\frac{1}{2}$
	·50	·68	$\frac{7}{8}$	Treble	9	$16\frac{3}{4}$	$3\frac{1}{2}$	Double	$5\frac{1}{4}$
	·68	·72	$\frac{7}{8}$	Quadruple	12	22	$3\frac{1}{2}$	Double	$5\frac{1}{4}$
	·72	·84	1	Quadruple	14	25	4	Double	6
	·84	·94	1	Quadruple	14	25	4	Treble	$8\frac{1}{2}$
	·94	1·04	$1\frac{1}{8}$	Quadruple	16	$28\frac{1}{4}$	$4\frac{1}{2}$	Treble	$9\frac{1}{2}$

H D.R. IN WAY OF STRENGTHENING OF BOTTOM FORD. (SEE SECT 8)

NOTES.—TABLE 52 (B).

1. Treble riveted double butt straps may be fitted as an alternative to quintuple riveted end laps.

2. The number of rows of rivets in seams all fore and aft is to be regulated by the MAXIMUM thickness of plating REQUIRED WITHIN THE ·4L (43) amidships. (Except as covered by Notes 7 and 8.)

3. Seams of side plating in all ships exceeding 275 feet in length are to be not less than double riveted. (Except as covered by Note 8.)

4. In seams of keel and sheerstrake the diameter of rivets and type of seam are to be regulated by the thickness of the adjacent plating. (Except as covered by Note 8).

5. For number of rivets between frames in seams of shell plating *see* **Table 52 (E)**. Where the form of the ship, forward and aft, is curved the spacing of the rivets is not to exceed $4\frac{1}{2}$ diameters. (For special requirements for ships above 500 feet *see* Note 7.) Where longitudinal framing is adopted the spacing of rivets in seams of shell plating is not to exceed $4\frac{1}{2}$ diameters, or 4 diameters in way of the strengthening of bottom forward.

6. For riveting in way of strengthening of bottom forward *see* **Section 8, clause 5.** For riveting in oil fuel bunkers *see* **Table 52 (G).** For riveting in way of strengthening for navigation in ice *see* **Section 10, clause 4.**

7. In ships above 500 feet in length in the three seams nearest to the neutral axis and for one-fourth of the ship's length in the forward and after bodies the following additions are to be made :—

Above 500 feet and not exceeding 525 feet an additional pair of rivets is to be fitted in each frame space.

Above 525 feet and not exceeding 550 feet two additional pairs of rivets are to be fitted in each frame space.

Above 550 feet and not exceeding 600 feet one seam, and in ships exceeding 600 feet two seams, are to be treble riveted, two additional pairs of rivets being fitted in each frame space in the other seam or seams.

In all the above ships one additional pair of rivets only need be fitted in way of 27 inch frame spacing. STRENGTH DK.

8. In ships where the draught does not exceed ·7D (D being measured to the uppermost continuous deck) and the riveting required by **Table 19** for the strength deck stringer angle is single, the lower edge of the sheerstrake may also be single riveted.

9. Seams of long bridges may be single riveted where the riveting required by **Table 19** is single but are to be double riveted for four frame spaces at the ends.

10. Seams of poops, short bridges and forecastles may be single riveted.

11. In single riveted seams the rivet is to pass through the frame. In double riveted seams one frame rivet (that adjacent to the caulking edge) is to pass through the seams at each frame except where the frames or edges of the plating are joggled when both rivets are to pass through the frame. In treble riveted seams two frame rivets, the upper and the lower, are to pass through the seams at each frame.

TABLE 52
(SEE CONTINUATION.)

RIVETING.

C.

END LAPS AND SEAMS OF DECK PLATING.

ITEM.	THICKNESS. Above.	THICKNESS. Not exceeding.	END LAPS AND BUTT STRAPS. Diameter of Rivets.	Type of End Lap and Single Butt Strap.	Breadth. End Laps.	Breadth. Butt Strap.	Spacing of Rivets. Centre to Centre.	SEAMS. Type of Seam.	SEAMS. Breadth.
	Inches.	Inches.	Inches.		Inches.	Inches.	Inches.		Inches.
Strength deck stringer plates for ·4L amidships.		·36	$\frac{5}{8}$	Double	$4\frac{1}{4}$	8	$2\frac{1}{2}$		
	·36	·42	$\frac{3}{4}$	Double	5	$9\frac{3}{4}$	3		
	·42	·50	$\frac{3}{4}$	Treble	$7\frac{1}{2}$	$14\frac{1}{4}$	3	*See*	
	·50	·68	$\frac{7}{8}$	Treble	9	$16\frac{3}{4}$	$3\frac{1}{2}$		
	·68	·72	$\frac{7}{8}$	Quadruple	12	22	$3\frac{1}{2}$	Note	
	·72	·84	1	Quadruple	14	25	4		
	·84	·94	1	Quintuple	$17\frac{1}{2}$		$4\frac{1}{2}$	2	
	·94	1·14	$1\frac{1}{8}$	Quintuple	20		5		
	1·14	1·26	$1\frac{1}{4}$	Quintuple	$22\frac{1}{2}$		$5\frac{5}{8}$		
Strength deck stringer plates at ends. Lower deck stringer plates. Deck tie plates.		·36	$\frac{5}{8}$	Double	$4\frac{1}{4}$	8	$2\frac{3}{4}$		
	·36	·42	$\frac{3}{4}$	Double	5	$9\frac{3}{4}$	$3\frac{3}{8}$		
	·42	·50	$\frac{3}{4}$	Treble	$7\frac{1}{2}$	$14\frac{1}{4}$	$3\frac{3}{8}$	*See*	
	·50	·68	$\frac{7}{8}$	Treble	9	$16\frac{3}{4}$	4		
	·68	·72	$\frac{7}{8}$	Quadruple	12	22	4	Note	
	·72	·94	1	Quadruple	14	25	$4\frac{1}{2}$	2	
	·94	1·14	$1\frac{1}{8}$	Quadruple	16	$28\frac{1}{4}$	5		
	1·14	1·26	$1\frac{1}{4}$	Quadruple	18	$31\frac{1}{2}$	$5\frac{5}{8}$		
Strength deck plating for ·4L amidships.		·36	$\frac{5}{8}$	Double	$4\frac{1}{4}$	8	$2\frac{1}{2}$	Single	$2\frac{1}{4}$
	·36	·48	$\frac{3}{4}$	Double	5	$9\frac{3}{4}$	3	Single	$2\frac{1}{2}$
	·48	·50	$\frac{3}{4}$	Treble	$7\frac{1}{2}$	$14\frac{1}{4}$	3	Single	$2\frac{1}{2}$
	·50	·68	$\frac{7}{8}$	Treble	9	$16\frac{3}{4}$	$3\frac{1}{2}$	Single	3
	·68	·72	$\frac{7}{8}$	Quadruple	12	22	$3\frac{1}{2}$	Single	3
	·72	·76	1	Quadruple	14	25	4	Single	$3\frac{1}{2}$
	·76	·94	1	Quadruple	14	25	4	Double	6
	·94	1·14	$1\frac{1}{8}$	Quadruple	16	$28\frac{1}{4}$	$4\frac{1}{2}$	Double	$6\frac{3}{4}$
(106) RULE Lower deck plating for ·4L amidships.		·36	$\frac{5}{8}$	Double	$4\frac{1}{4}$	8	$2\frac{3}{4}$	Single	$2\frac{1}{4}$
	·36	·48	$\frac{3}{4}$	Double	5	$9\frac{3}{4}$	$3\frac{3}{8}$	Single	$2\frac{1}{2}$
	·48	·50	$\frac{3}{4}$	Treble	$7\frac{1}{2}$	$14\frac{1}{4}$	$3\frac{3}{8}$	Single	$2\frac{1}{2}$
	·50	·68	$\frac{7}{8}$	Treble	9	$16\frac{3}{4}$	4	Single	3
Deck plating at ends.		·36	$\frac{5}{8}$	Single	$2\frac{1}{2}$	$4\frac{1}{2}$	$2\frac{3}{4}$	Single	$2\frac{1}{4}$
	·36	·42	$\frac{3}{4}$	Single	3	$5\frac{1}{4}$	$3\frac{3}{8}$	Single	$2\frac{1}{2}$
	·42	·50	$\frac{3}{4}$	Double	5	$9\frac{3}{4}$	$3\frac{3}{8}$	Single	$2\frac{1}{2}$
	·50	·54	$\frac{7}{8}$	Double	6	$11\frac{1}{4}$	4	Single	3
	·54	·68	$\frac{7}{8}$	Treble	9	$16\frac{3}{4}$	4	Single	3
	·68	·76	$\frac{7}{8}$ & 1"	QUAD.				SINGLE	
	·76	·94		QUAD.				DOUBLE.	

(105) BUTTS OF DECK PLATING WITHIN LINE OF OPENINGS NEED ONLY BE SINGLE RIVETED.

NOTES.—TABLE 52 (C).

1. Treble riveted double butt straps may be fitted as an alternative to quintuple riveted end laps.

2. In seams of stringer plates the diameter of rivets and type of seam are to be regulated by the thickness of the adjacent deck plating.

3. For number of rivets between beams in seams of deck plating *see* **Table 52 (E)**. The spacing of rivets in seams not parallel with the middle line of the ship is not to exceed $4\frac{1}{2}$ diameters. Where longitudinal framing is adopted the spacing of rivets in seams of deck plating is not to exceed $4\frac{1}{2}$ diameters.

4. Where the riveting is not otherwise required to be increased the seams and butts of deck plating over oil fuel bunkers may be single riveted if not more than 28 feet below the top of the overflow ; elsewhere the riveting is to be double.

5. For riveting of stringer angles on strength decks *see* **Table 19.** For riveting of stringer angles on lower decks *see* **Table 52 (F).**

RIVETING.

TABLE 52
(SEE CONTINUATION.)

D.

END LAPS AND SEAMS OF DOUBLE BOTTOMS.

ITEM.	THICKNESS.		END LAPS AND BUTT STRAPS.					SEAMS.	
	Above.	Not exceeding.	Diameter of Rivets.	Type of End Lap and Single Butt Strap.	Breadth.		Spacing of Rivets. Centre to Centre.	Type of Seam.	Breadth.
					End Laps.	Butt Strap.			
	Inches.	Inches	Inches.		Inches.	Inches.	Inches.		Inches.
Inner bottom middle line strake. Inner bottom plating for ·4L amidships. Margin plates. Centre and side girders (butts).		·36	$\frac{5}{8}$	Double	$4\frac{1}{4}$	8	$2\frac{1}{2}$	Single	$2\frac{1}{4}$
	·36	·48	$\frac{3}{4}$	Double	5	$9\frac{3}{4}$	3	Single	$2\frac{1}{2}$
	·48	·50	$\frac{3}{4}$	Treble	$7\frac{1}{2}$	$14\frac{1}{4}$	3	Double	$4\frac{1}{2}$
	·50	·68	$\frac{7}{8}$	Treble	9	$16\frac{3}{4}$	$3\frac{1}{2}$	Double	$5\frac{1}{4}$
	·68	·72	$\frac{7}{8}$	Quadruple	12	22	$3\frac{1}{2}$	Double	$5\frac{1}{4}$
	·72	·94	1	Quadruple	14	25	4		
Inner bottom plating at ends.		·36	$\frac{5}{8}$	Single	$2\frac{1}{2}$	$4\frac{1}{2}$	$2\frac{1}{2}$	Single	$2\frac{1}{4}$
	·36	·42	$\frac{3}{4}$	Single	3	$5\frac{1}{4}$	3	Single	$2\frac{1}{2}$
	·42	·48	$\frac{3}{4}$	Double	5	$9\frac{3}{4}$	3	Single	$2\frac{1}{2}$
	·48	·50	$\frac{3}{4}$	Double	5	$9\frac{3}{4}$	3	Double	$4\frac{1}{2}$
	·50	·54	$\frac{7}{8}$	Double	6	$11\frac{1}{4}$	$3\frac{1}{2}$	Double	$5\frac{1}{4}$
	·54	·68	$\frac{7}{8}$	Treble	9	$16\frac{3}{4}$	$3\frac{1}{2}$	Double	$5\frac{1}{4}$

NOTES.—TABLE 52 (D).

1. In seams of middle line strake of inner bottom and margin plates the diameter of rivets and type of seam are to be regulated by the thickness of the adjacent inner bottom plating.

2. Where oil fuel is carried in the double bottom and ceiling is not fitted completely over the inner bottom the seams and end laps are to be not less than double riveted.

3. For number of rivets between frames in seams of inner bottom plating *see* **Table 52 (E)**. The spacing of rivets in seams not parallel with the middle line of the ship is not to exceed 4 diameters. Where longitudinal framing is adopted the spacing of rivets in seams of inner bottom plating is not to exceed 4 diameters.

TABLE 52

(SEE CONTINUATION.)

RIVETING.

E.

NUMBER OF RIVETS IN SEAMS OF PLATING BETWEEN FRAMES AND BEAMS EXCLUDING RIVETS IN FRAMES AND BEAMS.

FRAME OR BEAM SPACING	THICKNESS OF SHELL AND DECK PLATING IN INCHES.						THICKNESS OF INNER BOTTOM PLATING IN INCHES.		
	Not exceeding ·36	Above ·36 and not exceeding ·50	Above ·50 and not exceeding ·72	Above ·72 and not exceeding ·94	Above ·94 and not exceeding 1·14	Above 1·14 and not exceeding 1·26	Not exceeding ·36	Above ·36 and not exceeding ·50	Above ·50 and not exceeding ·72
	DIAMETER OF RIVET IN INCHES.						DIAMETER OF RIVET IN INCHES.		
	$\frac{5}{8}$	$\frac{3}{4}$	$\frac{7}{8}$	1	$1\frac{1}{8}$	$1\frac{1}{4}$	$\frac{5}{8}$	$\frac{3}{4}$	$\frac{7}{8}$
INCHES.	NUMBER OF RIVETS IN EACH ROW.						NUMBER OF RIVETS IN EACH ROW.		
20	7*	5					7	6	
20½	7	5					7	6	
21	7	6*	5				7	6	5
21½	7	6	5				7	6	5
22	7	6	5				8	6	5
22½	7	6	5				8	6	5
23	8*	7*	5	5			8	7	6
23½		7*	5	5			8	7	6
24		7*	6*	5			8	7	6
24½		7*	6*	5			9	7	6
25		7	6	5			9	7	6
25½		7	6	5				7	7
26		7	6	5	5			8	7
26½		7	6	5	5			8	7
27		8*	7*	6*	5			8	7
27½		8*	7*	6*	5			8	7
28		8*	7*	6*	5	5		8	7
28½		8	7*	6	5	5		8	7
29		8	7	6	5	5			8
29½		8	7	6	5	5			8
30		8	7	6	5	5			8
30½		8	7	6	6*	5			8
31		9	7	6	6*	5			8
31½			7	6	6	5			8
32			8*	7*	6	5			8
32½			8*	7*	6	5			8
33			8	7	6	5			9
33½			8	7	6	5			9
34			8	7	6	6			9
34½			8	7	6	6			9
35			8	7	6	6			9
35½			8	7	7*	6			9
36			8	7	7*	6			9

The number of rivets in deck seams may be reduced by one where indicated thus.*

SPACING = FR. SPACING / m + 1

F.

NUMBER OF RIVETS BETWEEN FRAMES IN EACH FLANGE OF THE ANGLES CONNECTING STRINGER PLATES TO SHELL AND INTERCOSTAL GIRDERS TO SHELL AND INNER BOTTOM.

FRAME SPACING. INCHES.	DIAMETER OF RIVET IN INCHES.			
	$\frac{5}{8}$	$\frac{3}{4}$	$\frac{7}{8}$	1
Above — not exceeding	NUMBER OF RIVETS.			
— and 24	5	4	4	
24 „ 27	6	5	5	4
27 „ 30	7	6	5	5
30 „ 33		7	6	5
33 „ 36			7	6

For strength deck stringer angles see **Table 19.**

* TO BE ALTERED (J.M.M. 5/9/51.)

RIVETING.

TABLE 52
(SEE CONTINUATION.)

G.

SPACING OF RIVETS IN VARIOUS STRUCTURAL CONNECTIONS.

The breadths of flanges of connecting angles are generally to be not less than four times the rivet diameter for rivets up to $\frac{7}{8}$ inch in diameter and three and a half times for rivets 1 inch and above in diameter.

The distance from the centre of the rivet hole to the edge of the angle is to be not less than one and a half rivet diameters.

ITEM.	MAXIMUM SPACING OF RIVETS CENTRE TO CENTRE IN DIAMETERS.
FRAMING.	
Hold frames to shell ... Spacing not over 29 inches	7
Hold frames to shell ... „ over 29 inches and up to 32 inches	$6\frac{1}{2}$
Hold frames to shell ... „ „ 32 „ „ „ 34 „	6
Hold frames to shell ... „ „ 34 „	$5\frac{1}{2}$
Hold frames to shell ... in deep, oil fuel and peak tanks	$5\frac{1}{2}$
Hold frames to shell ... in panting region (**Section 9**)	$5\frac{1}{2}$
Reversed frames to frames	7
Frames to tank side brackets—spacing not to exceed 7 diameters	*See* **Table 11.**
'Tween deck frames to shell	7
Intermediate frames to shell (**Section 10, clause 4**)	7
Bottom frames to shell and floors: Spacing not over 32 inches	7
Bottom frames to shell and floors: „ over 32 inches and up to 34 inches	$6\frac{1}{2}$
Bottom frames to shell and floors: „ over 34 inches	6
Bottom frames to shell and floors: in the forward ·25L (WHERE A SINGLE BAR D.R. IS FITTED RIVETS TO FLOORS MAY BE 6¼ DIAS.	$5\frac{1}{2}$
Bottom frames to shell and floors: in way of longitudinal framing (*see also* **Section 5, clause 6**(*c*))	5
Bottom frames to shell and floors: „ „ „ „ „ when spacing of floors exceeds 8 feet, for two spaces of longitudinals at each end	4
Bottom longitudinals to shell in the forward ·25L	$5\frac{1}{2}$
„ „ „ „ remainder	6
Floors and cross ties in fore peak	6
„ „ „ after peak	5
DOUBLE BOTTOMS.	
Keel angles, single riveted	5
Keel angles, double riveted	$6\frac{1}{2}$
Centre girder top angles (except in way of centre line bulkhead)	7
Centre girder top angles (in way of centre line bulkhead)	5
Vertical angles, floors to centre girder	5
Vertical angles, floors to intercostal side girders	7
Top and bottom angles of intercostal side girders	*See* **Table 52 (F).**
Reversed frames to floors and inner bottom	7
Longitudinals to inner bottom	6
Margin angle	$4\frac{1}{2}$
Bracket floors and longitudinal framing	*See* **Table 8.**
Margin connection to tank side brackets	*See* **Table 11.**
Boundary angles and stiffeners of watertight floors	5
Riveting in way of heavy oil engines—to be specially considered.	
SINGLE BOTTOMS.	
Keel angles	5
Reversed frames	7
Floors to centre keelson (double connection where floors cut)	4
Foundation plates to reversed frames	4
Continuous keelson angles	7
Butts of keelsons and foundation plates	4
Attachment of reversed frames to side keelsons—not less than 2 rivets.	

Continued on next page.

TABLE 52
(SEE CONTINUATION.)

RIVETING.

G.

SPACING OF RIVETS IN VARIOUS STRUCTURAL CONNECTIONS.

ITEM.	MAXIMUM SPACING OF RIVETS CENTRE TO CENTRE IN DIAMETERS.
WATERTIGHT BULKHEADS, FLATS AND TUNNELS.	
Horizontal connections of plating may be single riveted.	
Vertical connections of plating and boundary angles are to be double riveted when more than 35 feet below the top of the bulkhead.	
Overlaps of plating	4½
Boundary angles to shell, inner bottom and decks	5
Boundary angles to bulkhead	4½
Stiffeners (except as below)	7
Stiffeners, lugged or unattached, for 15 per cent of length at each end	4
BULKHEADS OF DEEP TANKS, PEAK TANKS AND OIL CARGO TANKS.	
Overlaps of plating and boundary angles to be single or double riveted as for watertight bulkheads.	
Overlaps of plating	4
Stiffeners, bracketed	6
OIL FUEL BUNKERS.	
Where not otherwise required to be increased the overlaps of plating of bulkheads, shell and deck and the stringer angle may be single riveted if not more than 28 feet below the top of the overflow or 16 feet below the top of the tank; elsewhere the riveting is to be double. Centre line bulkheads may be single riveted throughout.	
Overlaps of bulkhead, inner bottom, and deck plating	4
Deck stringer angle	4
Boundary angles, double riveted	5
Stiffeners, bracketed	6
Horizontal girders to shell and bulkheads (*see* also **Section 20, clause 3**)	4½
Horizontal girders—brackets (double riveted)	4½
Horizontal girders—face angles	7
NON-WATERTIGHT BULKHEADS.	
Overlaps of plating	6
Boundary angle on inner bottom, horizontal flange (*see also* **Section 18, clause 1** (*b*))	5
Boundary angle elsewhere	7
Stiffeners	7
DECKS.	
Stringer angle on strength decks	*See* Table 19.
Stringer angle on lower decks	*See* Table 52 (F).
(99) SEAMS OF DECK PLATING OVER DEEP TANKS, PEAK TANKS AND OIL CARGO TANKS	4 ½
BEAMS AND DECK LONGITUDINALS.	
Beams to deck	7
Beams at crowns of deep tanks, peak tanks and oil fuel tanks	6
Strong beams at ends of hatchways, deck connections (*see* also Deck Girders)	5
Half beams to hatch coamings and casings—lugs of same thickness as coaming with 2 rivets in each flange for beams not exceeding 8 inches, and 3 rivets for beams exceeding 8 inches in depth.	
Longitudinals to deck	6

Continued on next page.

RIVETING.

TABLE 52
(CONCLUDED.)

G.
SPACING OF RIVETS IN VARIOUS STRUCTURAL CONNECTIONS.

ITEM.	MAXIMUM SPACING OF RIVETS CENTRE TO CENTRE IN DIAMETERS.
DECK GIRDERS AND TRANSVERSES.	
Deck connections (*see* also **Section 15, clause 3**)	5
Face section, not exceeding 6 square inches area, to web	7
Face section, exceeding 6 square inches area, to web	6
Brackets at ends of girders, in each row	5
Butts of girders	4
PILLARS.	
Heads and heels of solid pillars	*See* **Table 31.**
Seams of tubular pillars	5
Riveting of pillars built of rolled sections	7
End connections of widely spaced pillars	5
HATCHWAYS.	
Deck angles to deck and coaming	5
Deck angles to deck and coaming at corners	$4\frac{1}{2}$
Bulb angle stiffeners on coaming	7
Horizontal stiffeners on coaming where forming watertight recess	5
Hatch beam angles	7
VENTILATORS.	
Deck angle to deck and coaming (*see* also **Section 24, clause 2**(*b*))	4
DECKHOUSES.	
Overlaps of outer casings	5
Overlaps of inner casings	6
Foundation angles	5
Stiffeners	7
MASTS.	
End laps are to be treble riveted and seams single riveted.	
Overlaps of plating	5
RUDDERS.	
Spacing of rivets in arms (*see* also **Section 26, clause 7**)	$4\frac{1}{2}$
STEMS AND STERNFRAMES.	
Connections to shell plating: diameter of rivet with solid sections to be $\frac{1}{4}$ inch greater than required for the thickness of the plating and $\frac{1}{8}$ inch greater for castings or built frames but need not exceed $1\frac{1}{8}$ inch.	5
In ships above 350 feet in length shell plating is to be connected to sternframe below the boss by three rows of rivets.	
Connection to transom plate: for ships not exceeding 300 feet in length by two single riveted angles, in ships above 300 feet in length by two double riveted angles	5

FOR REDUCTION FOR TAYCO CABLE SEE PAGE 63.

TABLE 53

EQUIPMENT.

* EQUIPMENT NUMERAL.	Letters for Equipment as inserted in Register Book, Column 7.	ANCHORS. Number. Bowers.	Number. Stream.	Bower Anchors. Stockless. Weight.	Stockless. Test.	Stockless. Collective Weight.	Ex Stock. Weight.	Ex Stock. Test.	Ex Stock. Collective Weight.	Stream Anchor. Ex Stock. Weight.	Stream Anchor. Ex Stock. Test.	CHAIN CABLES. Wrought Iron Stud Chain Cables. Length.	Minimum Size.	Proved to Statutory Test.	Breaking Test.	Minimum Weight
				Cwts.	Tons.	Cwts.	Cwts.	Tons.	Cwts.	Cwts.	Tons.	Fms.	Inches.	Tons.	Tons.	Cwts.
3000	*a*	2	1	$4\frac{1}{2}$	$6\frac{17}{20}$	$8\frac{3}{4}$	$3\frac{1}{2}$	$5\frac{18}{20}$	7	$\frac{3}{4}$	—	120	$\frac{11}{16}$	$8\frac{5}{10}$	$12\frac{3}{4}$	21
3600	*b*	2	1	$5\frac{1}{4}$	$7\frac{11}{20}$	$10\frac{1}{2}$	$4\frac{1}{4}$	$6\frac{12}{20}$	$8\frac{1}{2}$	$1\frac{1}{4}$	$3\frac{13}{20}$	120	$\frac{12}{16}$	$10\frac{1}{8}$	$15\frac{1}{8}$	34
4200	*c*	2	1	$6\frac{1}{4}$	$8\frac{10}{20}$	$12\frac{1}{2}$	5	$7\frac{7}{20}$	10	$1\frac{3}{4}$	$4\frac{4}{20}$	135	$\frac{13}{16}$	$11\frac{7}{8}$	$17\frac{8}{10}$	46
4800	*d*	2	1	$7\frac{1}{4}$	$9\frac{9}{20}$	$14\frac{1}{4}$	$5\frac{3}{4}$	8	$11\frac{1}{2}$	$2\frac{1}{4}$	$4\frac{15}{20}$	165	$\frac{14}{16}$	$13\frac{3}{4}$	$20\frac{5}{8}$	64
5400	*e*	2	1	$8\frac{1}{4}$	$10\frac{7}{20}$	$16\frac{1}{4}$	$6\frac{1}{2}$	$8\frac{15}{20}$	13	$2\frac{3}{4}$	$5\frac{5}{20}$	165	$\frac{15}{16}$	$15\frac{8}{10}$	$23\frac{7}{10}$	74
6000	*f*	2	1	9	$11\frac{2}{20}$	18	$7\frac{1}{4}$	$9\frac{9}{20}$	$14\frac{1}{2}$	3	$5\frac{10}{20}$	165	1	18	27	84
6700	*g*	3	1	$10\frac{1}{4}$	$12\frac{4}{20}$	$29\frac{1}{4}$	$8\frac{1}{4}$	$10\frac{7}{20}$	$23\frac{1}{2}$	$3\frac{1}{2}$	$5\frac{18}{20}$	165	$1\frac{1}{16}$	$20\frac{3}{10}$	$30\frac{4}{10}$	95
7400	*h*	3	1	$12\frac{1}{2}$	$14\frac{6}{20}$	$35\frac{1}{2}$	10	12	$28\frac{1}{2}$	4	$6\frac{7}{20}$	195	$1\frac{2}{16}$	$22\frac{3}{4}$	$34\frac{1}{8}$	126
8100	*i*	3	1	$14\frac{1}{2}$	$16\frac{1}{20}$	$41\frac{3}{4}$	$11\frac{3}{4}$	$13\frac{12}{20}$	$33\frac{1}{2}$	$4\frac{1}{4}$	$6\frac{12}{20}$	195	$1\frac{3}{16}$	$25\frac{3}{8}$	38	141
8900	*j*	3	1	$16\frac{3}{4}$	18	48	$13\frac{1}{2}$	$15\frac{3}{20}$	$38\frac{1}{2}$	$4\frac{3}{4}$	$7\frac{2}{20}$	210	$1\frac{4}{16}$	$28\frac{1}{8}$	$42\frac{1}{8}$	168
9700	*k*	3	1	19	$19\frac{17}{20}$	$54\frac{1}{4}$	$15\frac{1}{4}$	$16\frac{14}{20}$	$43\frac{1}{2}$	$5\frac{1}{4}$	$7\frac{11}{20}$	210	$1\frac{5}{16}$	31	$46\frac{1}{2}$	185
10600	*l*	3	1	$21\frac{1}{4}$	$21\frac{16}{20}$	$60\frac{1}{2}$	17	$18\frac{5}{20}$	$48\frac{1}{2}$	$5\frac{3}{4}$	8	210	$1\frac{6}{16}$	34	51	203
11600	*m*	3	1	$23\frac{1}{4}$	$23\frac{6}{20}$	$66\frac{3}{4}$	$18\frac{3}{4}$	$19\frac{13}{20}$	$53\frac{1}{2}$	6	$8\frac{5}{20}$	210	$1\frac{7}{16}$	$37\frac{1}{8}$	$55\frac{5}{8}$	222
12700	*n*	3	1	$25\frac{1}{2}$	$25\frac{3}{20}$	73	$20\frac{1}{2}$	$21\frac{3}{20}$	$58\frac{1}{2}$	$6\frac{1}{2}$	$8\frac{15}{20}$	210	$1\frac{8}{16}$	$40\frac{5}{10}$	$58\frac{7}{10}$	242
13900	*o*	3	1	28	$27\frac{2}{20}$	80	$22\frac{1}{2}$	$22\frac{15}{20}$	64	7	$9\frac{5}{20}$	240	$1\frac{9}{16}$	$43\frac{9}{10}$	$61\frac{4}{10}$	298
15200	*p*	3	1	$30\frac{1}{2}$	29	87	$24\frac{1}{2}$	$24\frac{6}{20}$	$69\frac{1}{2}$	$7\frac{3}{4}$	$9\frac{18}{20}$	240	$1\frac{10}{16}$	$47\frac{5}{10}$	$66\frac{5}{10}$	319
16700	*q*	3	1	33	$30\frac{17}{20}$	94	$26\frac{1}{2}$	26	75	$8\frac{1}{2}$	$10\frac{12}{20}$	240	$1\frac{11}{16}$	$51\frac{1}{4}$	$71\frac{3}{4}$	344
18500	*r*	3	1	$35\frac{1}{2}$	$32\frac{15}{20}$	101	$28\frac{1}{2}$	$27\frac{10}{20}$	81	$9\frac{1}{4}$	$11\frac{6}{20}$	240	$1\frac{12}{16}$	$55\frac{1}{8}$	$77\frac{1}{8}$	370
20600	*s*	3	1	$38\frac{3}{4}$	$34\frac{19}{20}$	110	31	$29\frac{7}{20}$	88	10	12	240	$1\frac{13}{16}$	$59\frac{1}{8}$	$82\frac{3}{4}$	397
22700	*t*	3	1	42	$37\frac{2}{20}$	$119\frac{1}{2}$	$33\frac{1}{2}$	$31\frac{5}{20}$	$95\frac{1}{2}$	11	$12\frac{17}{20}$	240	$1\frac{14}{16}$	$63\frac{1}{4}$	$88\frac{5}{10}$	425
25000	*u*	3	1	45	$39\frac{5}{20}$	128	36	$33\frac{2}{20}$	103	12	$13\frac{17}{20}$	270	$1\frac{15}{16}$	$67\frac{5}{10}$	$94\frac{5}{10}$	511
27300	*v*	3	1	$48\frac{3}{4}$	$41\frac{11}{20}$	139	39	$35\frac{2}{20}$	111	13	$14\frac{15}{20}$	270	2	72	$100\frac{8}{10}$	538
29700	*w*	3	1	$52\frac{1}{2}$	$43\frac{18}{20}$	$149\frac{1}{2}$	42	$37\frac{2}{20}$	$119\frac{1}{2}$	14	$15\frac{12}{20}$	270	$2\frac{1}{16}$	$76\frac{5}{10}$	$107\frac{1}{10}$	573
32200	*x*	3	1	$56\frac{1}{4}$	$46\frac{3}{20}$	160	45	$39\frac{5}{20}$	128	15	$16\frac{10}{20}$	270	$2\frac{2}{16}$	$81\frac{1}{4}$	$113\frac{3}{4}$	608
34800	*y*	3	1	60	$48\frac{7}{20}$	$170\frac{1}{2}$	48	$41\frac{2}{20}$	$136\frac{1}{2}$	$16\frac{1}{4}$	$17\frac{11}{20}$	270	$2\frac{3}{16}$	$86\frac{1}{8}$	$120\frac{5}{10}$	645
37600	*z*	3	1	$63\frac{3}{4}$	$50\frac{7}{20}$	182	51	43	$145\frac{1}{2}$	$17\frac{1}{2}$	$18\frac{12}{20}$	270	$2\frac{4}{16}$	$91\frac{1}{8}$	$127\frac{5}{10}$	682
40400	*a*†	3	1	68	$52\frac{12}{20}$	$194\frac{1}{2}$	$54\frac{1}{2}$	$45\frac{1}{20}$	$155\frac{1}{2}$	19	$19\frac{17}{20}$	270	$2\frac{5}{16}$	$96\frac{1}{4}$	$134\frac{3}{4}$	720
43200	*b*†	3	1	$72\frac{1}{2}$	55	207	58	$47\frac{5}{20}$	$165\frac{1}{2}$	$20\frac{1}{2}$	$21\frac{3}{20}$	300	$2\frac{6}{16}$	$101\frac{5}{10}$	$142\frac{1}{10}$	844
46000	*c*†	3	1	77	$57\frac{5}{20}$	$219\frac{1}{2}$	$61\frac{1}{2}$	$49\frac{3}{20}$	$175\frac{1}{2}$	22	$22\frac{7}{20}$	300	$2\frac{7}{16}$	$106\frac{9}{10}$	$149\frac{5}{8}$	890
48800	*d*†	3	1	$81\frac{1}{4}$	$59\frac{2}{20}$	232	65	51	$185\frac{1}{2}$	$23\frac{1}{2}$	$23\frac{10}{20}$	300	$2\frac{8}{16}$	$112\frac{5}{10}$	$157\frac{5}{10}$	940
51600	*e*†	3	1	$85\frac{1}{2}$	$61\frac{5}{20}$	$244\frac{1}{2}$	$68\frac{1}{2}$	$52\frac{18}{20}$	$195\frac{1}{2}$	25	$24\frac{15}{20}$	300	$2\frac{9}{16}$	$116\frac{7}{10}$	$163\frac{3}{8}$	989
54600	*f*†	3	1	90	$63\frac{5}{20}$	$257\frac{1}{2}$	72	$54\frac{15}{20}$	206	$26\frac{1}{2}$	26	300	$2\frac{10}{16}$	$120\frac{9}{10}$	$169\frac{1}{4}$	1040
57600	*g*†	3	1	95	$65\frac{7}{20}$	271	76	$56\frac{15}{20}$	217	28	$27\frac{2}{20}$	330	$2\frac{11}{16}$	$125\frac{1}{10}$	$175\frac{1}{8}$	1200
60600	*h*†	3	1	100	$67\frac{5}{20}$	285	80	$58\frac{10}{20}$	228	$29\frac{1}{2}$	$28\frac{5}{20}$	330	$2\frac{12}{16}$	$129\frac{3}{10}$	181	1258
63800	*i*†	3	1	$104\frac{1}{2}$	$68\frac{19}{20}$	298	$83\frac{1}{2}$	$60\frac{5}{20}$	238	31	$29\frac{7}{20}$	330	$2\frac{13}{16}$	$133\frac{4}{10}$	$186\frac{3}{4}$	1317
67000	*j*†	3	1	109	$70\frac{12}{20}$	311	87	$61\frac{17}{20}$	248	$32\frac{1}{2}$	$30\frac{10}{20}$	330	$2\frac{14}{16}$	$137\frac{6}{10}$	$192\frac{5}{8}$	1378
70200	*k*†	3	1	$113\frac{1}{2}$	$72\frac{6}{20}$	324	91	$63\frac{12}{20}$	259	34	$31\frac{12}{20}$	330	$2\frac{15}{16}$	$141\frac{7}{10}$	$198\frac{3}{8}$	1440
73400	*l*†	3	1	118	74	336	$94\frac{1}{2}$	$65\frac{3}{20}$	269	$35\frac{1}{2}$	$32\frac{15}{20}$	330	3	$145\frac{8}{10}$	$204\frac{1}{10}$	1503
76800	*m*†	3	1	$122\frac{1}{2}$	$75\frac{10}{20}$	349	98	$66\frac{10}{20}$	279	$37\frac{1}{4}$	$33\frac{18}{20}$	330	$3\frac{1}{16}$	$149\frac{8}{10}$	$209\frac{7}{10}$	1568
80200	*n*†	3	1	127	$76\frac{18}{20}$	362	$101\frac{1}{2}$	$67\frac{16}{20}$	290	39	$35\frac{2}{20}$	330	$3\frac{2}{16}$	$153\frac{3}{4}$	$215\frac{1}{4}$	1634
83800	*o*†	3	1	132	$78\frac{10}{20}$	376	$105\frac{1}{2}$	$69\frac{6}{20}$	301	$40\frac{3}{4}$	$36\frac{6}{20}$	330	$3\frac{3}{16}$	$157\frac{7}{10}$	$220\frac{3}{4}$	1701
87600	*p*†	3	1	137	$80\frac{1}{20}$	390	$109\frac{1}{2}$	$70\frac{16}{20}$	312	$42\frac{1}{2}$	$37\frac{10}{20}$	330	$3\frac{4}{16}$	$161\frac{6}{10}$	$226\frac{2}{10}$	1769
91600	*q*†	3	1	142	$81\frac{12}{20}$	404	$113\frac{1}{2}$	$72\frac{6}{20}$	324	$44\frac{1}{4}$	$38\frac{15}{20}$	330	$3\frac{5}{16}$	$165\frac{4}{10}$	$231\frac{5}{10}$	1839
95800	*r*†	3	1	$147\frac{1}{2}$	$83\frac{6}{20}$	420	118	74	336	46	$39\frac{17}{20}$	330	$3\frac{6}{16}$	$169\frac{1}{8}$	$236\frac{3}{4}$	1910
100200	*s*†	3	1	153	85	436	$122\frac{1}{2}$	$75\frac{10}{20}$	349	$47\frac{3}{4}$	$40\frac{19}{20}$	330	$3\frac{7}{16}$	$172\frac{3}{4}$	$241\frac{8}{10}$	1988
105000	*t*†	3	1	159	$86\frac{10}{20}$	452	127	$76\frac{18}{20}$	362	$49\frac{1}{2}$	$42\frac{1}{20}$	330	$3\frac{8}{16}$	$176\frac{4}{10}$	$246\frac{9}{10}$	2057

* Where the equipment numeral lies between any two consecutive numbers given in the Table the equipment is to be governed by the greater.

EQUIPMENT. TABLE 53

STREAM CHAIN OR STEEL WIRE.					TOWLINE, FIBRE OR STEEL WIRE.				HAWSERS AND WARPS. FIBRE OR STEEL WIRE.							Letters for Equipment as inserted in Register Book, Column 7	*EQUIPMENT NUMERAL.
	Wrought Iron Chain.			Steel Wire.		Fibre.	Steel Wire.			Hawsers.			Warps.				
Length.	Size.	Minimum Weight. Stud Link.	Minimum Weight. Short Link.	Size.	Breaking Test.	Length.	Size.	Size.	Breaking Test.	Length of Each.	Number.	Fibre. Size.	Flexible Steel Wire Rope. Size. (*b*)	Number.	Fibre. Size.	Flexible Steel Wire Rope. Size. (*b*)	
Fathoms.	Inches.	Cwt.	Cwt.	Inches.	Tons.	Fathoms.	Inches.	Inches.	Tons.	Fathoms.		Inches.	Inches.		Inches.	Inches.	
45	$\frac{8}{16}$	$6\frac{1}{2}$	$7\frac{1}{4}$	—	—	75	$5\frac{1}{2}$	2	8·3	90	1	3	—	—	—	—	*a*	3000
45	$\frac{9}{16}$	8	$8\frac{3}{4}$	2	8·3	75	6	$2\frac{1}{4}$	10·8	90	1	4	—	—	—	—	*b*	3600
45	$\frac{9}{16}$	8	$8\frac{3}{4}$	2	8·3	75	6	$2\frac{1}{4}$	10·8	90	1	4	—	—	—	—	*c*	4200
45	$\frac{10}{16}$	$9\frac{3}{4}$	$10\frac{1}{2}$	$2\frac{1}{4}$	10·8	75	$6\frac{1}{2}$	$2\frac{1}{4}$	10·8	90	1	4	—	—	—	—	*d*	4800
45	$\frac{10}{16}$	$9\frac{3}{4}$	$10\frac{1}{2}$	$2\frac{1}{4}$	10·8	75	7	$2\frac{1}{2}$	13·2	90	1	5	$1\frac{3}{4}$	—	—	—	*e*	5400
45	$\frac{11}{16}$	11	12	$2\frac{1}{2}$	13·2	75	$7\frac{1}{2}$	$2\frac{1}{2}$	13·2	90	1	$5\frac{1}{2}$	2	—	—	—	*f*	6000
60	$\frac{11}{16}$	$14\frac{1}{2}$	$15\frac{3}{4}$	$2\frac{1}{2}$	13·2	75	$7\frac{1}{2}$	$2\frac{1}{2}$	13·2	90	1	$5\frac{1}{2}$	2	—	—	—	*g*	6700
60	$\frac{12}{16}$	$17\frac{1}{4}$	$18\frac{3}{4}$	$2\frac{3}{4}$	15·2	75	8	$2\frac{3}{4}$	15·2	90	1	6	$2\frac{1}{4}$	—	—	—	*h*	7400
60	$\frac{13}{16}$	$20\frac{1}{2}$	22	3	18·6	75	$8\frac{1}{2}$	$2\frac{3}{4}$	15·2	90	1	6	$2\frac{1}{4}$	—	—	—	*i*	8100
60	$\frac{13}{16}$	$20\frac{1}{2}$	22	3	18·6	75	$8\frac{1}{2}$	$2\frac{3}{4}$	15·2	90	1	6	$2\frac{1}{4}$	1	4	—	*j*	8900
60	$\frac{14}{16}$	$23\frac{1}{2}$	$25\frac{1}{2}$	$3\frac{1}{4}$	21·7	90	9	3	18·6	90	1	6	$2\frac{1}{4}$	1	5	$1\frac{3}{4}$	*k*	9700
60	$\frac{14}{16}$	$23\frac{1}{2}$	$25\frac{1}{2}$	$3\frac{1}{4}$	21·7	90	9	3	18·6	90	1	6	$2\frac{1}{4}$	1	5	$1\frac{3}{4}$	*l*	10600
60	$\frac{15}{16}$	27	29	$3\frac{1}{2}$	25·7	90	—	$3\frac{1}{4}$ (*a*)	21·7	90	1	6	$2\frac{1}{4}$	1	5	$1\frac{3}{4}$	*m*	11600
75	$\frac{15}{16}$	34	$35\frac{1}{2}$	$3\frac{1}{2}$	25·7	90	—	$3\frac{1}{4}$	21·7	90	1	6	$2\frac{1}{4}$	1	5	$1\frac{3}{4}$	*n*	12700
75	1	$38\frac{1}{4}$	$41\frac{1}{4}$	$3\frac{3}{4}$ (*a*)	29·3	90	—	$3\frac{1}{4}$	21·7	90	1	6	$2\frac{1}{4}$	1	5	$1\frac{3}{4}$	*o*	13900
75	1	$38\frac{1}{4}$	$41\frac{1}{4}$	$3\frac{3}{4}$	29·3	90	—	$3\frac{1}{4}$	21·7	90	2	6	$2\frac{1}{4}$	2	5	$1\frac{3}{4}$	*p*	15200
75	$1\frac{1}{16}$	$43\frac{1}{4}$	$46\frac{1}{4}$	4	33·2	90	—	$3\frac{1}{2}$	25·7	90	2	6	$2\frac{1}{4}$	2	5	$1\frac{3}{4}$	*q*	16700
75	$1\frac{1}{16}$	$43\frac{1}{4}$	$46\frac{1}{4}$	4	33·2	90	—	$3\frac{1}{2}$	25·7	90	2	6	$2\frac{1}{4}$	2	5	$1\frac{3}{4}$	*r*	18500
75	$1\frac{2}{16}$	$48\frac{1}{2}$	52	$4\frac{1}{4}$	36·4	90	—	4	33·2	90	2	7	$2\frac{1}{2}$	2	6	$2\frac{1}{4}$	*s*	20600
75	$1\frac{2}{16}$	$48\frac{1}{2}$	52	$4\frac{1}{4}$	36·4	100	—	4	33·2	90	2	7	$2\frac{1}{2}$	2	6	$2\frac{1}{4}$	*t*	22700
90	$1\frac{2}{16}$	$51\frac{1}{4}$	$62\frac{1}{4}$	$4\frac{1}{4}$	36·4	100	—	4	33·2	90	2	7	$2\frac{1}{2}$	2	6	$2\frac{1}{4}$	*u*	25000
90	$1\frac{3}{16}$	$65\frac{1}{4}$	$69\frac{3}{4}$	$4\frac{1}{2}$	43·3	120	—	4	33·2	90	2	7	$2\frac{1}{2}$	2	7	$2\frac{1}{2}$	*v*	27300
90	$1\frac{3}{16}$	$65\frac{1}{4}$	$69\frac{3}{4}$	$4\frac{1}{2}$	43·3	120	—	$4\frac{1}{2}$	43·3	90	2	7	$2\frac{1}{2}$	2	7	$2\frac{1}{2}$	*w*	29700
90	$1\frac{3}{16}$	$65\frac{1}{4}$	$69\frac{3}{4}$	$4\frac{1}{2}$	43·3	120	—	$4\frac{1}{2}$	43·3	90	2	7	$2\frac{1}{2}$	2	7	$2\frac{1}{2}$	*x*	32200
90	$1\frac{4}{16}$	72	77	$4\frac{3}{4}$	47·0	120	—	$4\frac{3}{4}$	47·0	90	2	8	$2\frac{3}{4}$	2	7	$2\frac{1}{2}$	*y*	34800
90	$1\frac{4}{16}$	72	77	$4\frac{3}{4}$	47·0	120	—	5	52·8	90	2	8	$2\frac{3}{4}$	2	7	$2\frac{1}{2}$	*z*	37600
90	$1\frac{5}{16}$	$79\frac{1}{2}$	85	5	52·8	120	—	$4\frac{3}{4}$	64·6	90	2	8	$2\frac{3}{4}$	2	7	$2\frac{1}{2}$	*a*†	40400
120	$1\frac{5}{16}$	106	$113\frac{1}{4}$	5	52·8	130	—	5	70·9	100	2	8	$2\frac{3}{4}$	2	8	$2\frac{3}{4}$	*b*†	43200
120	$1\frac{5}{16}$	106	$113\frac{1}{4}$	5	52·8	130	—	$5\frac{1}{4}$	77·5	100	2	8	$2\frac{3}{4}$	2	8	$2\frac{3}{4}$	*c*†	46000
120	$1\frac{6}{16}$	116	124	$4\frac{3}{4}$	64·6	130	—	$5\frac{1}{2}$	84·4	100	2	8	$2\frac{3}{4}$	2	8	$2\frac{3}{4}$	*d*†	48800
120	$1\frac{6}{16}$	116	124	$4\frac{3}{4}$	64·6	130	—	$5\frac{1}{2}$	84·4	100	2	8	$2\frac{3}{4}$	2	8	$2\frac{3}{4}$	*e*†	51600
120	$1\frac{7}{16}$	$126\frac{3}{4}$	$135\frac{1}{2}$	5	70·9	130	—	$5\frac{1}{2}$	84·4	100	2	8	$2\frac{3}{4}$	2	8	$2\frac{3}{4}$	*f*†	54600
120	$1\frac{8}{16}$	$138\frac{1}{4}$	$146\frac{1}{2}$	$5\frac{1}{2}$	84·4	130	—	$6\frac{1}{2}$	112·3	100	2	8	$2\frac{3}{4}$	2	8	$2\frac{3}{4}$	*g*†	57600
120	$1\frac{8}{16}$	$138\frac{1}{4}$	$146\frac{1}{2}$	$5\frac{1}{2}$	84·4	130	—	$6\frac{1}{2}$ (*c*)	112·3	120	2	8	$2\frac{3}{4}$	2	8	$2\frac{3}{4}$	*h*†	60600
120	$1\frac{9}{16}$	$149\frac{1}{4}$	159	$5\frac{1}{2}$	84·4	130	—	$6\frac{1}{2}$	112·3	120	2	8	$2\frac{3}{4}$	2	8	$2\frac{3}{4}$	*i*†	63800
120	$1\frac{10}{16}$	$159\frac{3}{4}$	$171\frac{1}{2}$	$5\frac{1}{2}$	84·4	130	—	$6\frac{1}{2}$	112·3	120	2	8	$2\frac{3}{4}$	2	8	$2\frac{3}{4}$	*j*†	67000
150	$1\frac{11}{16}$	$215\frac{1}{2}$	$231\frac{1}{2}$	6	99·1	140	—	7	130·7	120	3	8	$2\frac{3}{4}$	2	8	$2\frac{3}{4}$	*k*†	70200
150	$1\frac{12}{16}$	$231\frac{1}{2}$	$249\frac{1}{2}$	6 (*c*)	99·1	140	—	7	130·7	120	3	8	$2\frac{3}{4}$	2	8	$2\frac{3}{4}$	*l*†	73400
150	$1\frac{13}{16}$	$248\frac{1}{2}$	$268\frac{1}{2}$	6	99·1	140	—	7	130·7	120	3	8	$2\frac{3}{4}$	2	8	$2\frac{3}{4}$	*m*†	76800
150	$1\frac{13}{16}$	$248\frac{1}{2}$	$268\frac{1}{2}$	6	99·1	140	—	7	130·7	120	3	8	$2\frac{3}{4}$	3	8	$2\frac{3}{4}$	*n*†	80200
150	$1\frac{14}{16}$	$265\frac{3}{4}$	288	$6\frac{1}{2}$	112·3	140	—	7	130·7	120	3	8	$2\frac{3}{4}$	3	8	$2\frac{3}{4}$	*o*†	83800
150	$1\frac{14}{16}$	$265\frac{3}{4}$	288	$6\frac{1}{2}$	112·3	140	—	7	130·7	120	3	8	$2\frac{3}{4}$	3	8	$2\frac{3}{4}$	*p*†	87600
150	$1\frac{15}{16}$	284	309	$6\frac{1}{2}$	112·3	150	—	8	148·8	120	3	8	$2\frac{3}{4}$	3	8	$2\frac{3}{4}$	*q*†	91600
150	$1\frac{15}{16}$	284	309	$6\frac{1}{2}$	112·3	150	—	8 (*d*)	148·8	120	3	8	$2\frac{3}{4}$	3	8	$2\frac{3}{4}$	*r*†	95800
150	2	$299\frac{1}{4}$	330	7	130·7	150	—	8	148·8	120	3	8	$2\frac{3}{4}$	3	8	$2\frac{3}{4}$	*s*†	100200
150	2	$299\frac{1}{4}$	330	7	130·7	150	—	8	148·8	120	3	8	$2\frac{3}{4}$	3	8	$2\frac{3}{4}$	*t*†	105000

* Where the equipment numeral lies between any two consecutive numbers given in the Table the equipment is to be governed by the greater.

(*b*) 6 × 12 Flexible Steel Wire Ropes. (*c*) 6 × 24 Special Flexible Steel Wire Ropes. (*d*) 6 × 30 Special Flexible Steel Wire Ropes.

TABLE 54 EQUIPMENT FOR TUGS.

*EQUIPMENT NUMERAL.	ANCHORS.					WROUGHT IRON CHAIN.				HAWSERS.		WARPS.	
	Number.	Weight. Ex Stock.		Weight. Stockless.		Length.	Diameter.	Minimum Weight.		Length.	Size.	Length.	Size.
		1st Bower.	2nd & 3rd Bower.	1st Bower.	2nd & 3rd Bower.			Stud Link.	Short Link.				
		Cwts.	Cwts.	Cwts.	Cwts.	Fathoms.	Inches.	Cwts.	Cwts.	Fathoms.	Inches.	Fathoms.	Inches.
1440	2	2¼	2¼	3	3	60	10/16	13	14	60	4½	60	2½
1710	2	2½	2½	3¼	3¼	60	11/16	14½	15¾	60	4½	60	2½
1980	2	2¾	2¾	3½	3½	60	11/16	14½	15¾	60	4½	60	2½
2250	2	3	3	3¾	3¾	60	12/16	17¼	18¾	60	5	60	2½
2620	2	3½	3½	4½	4½	60	13/16	20½	22	60	5½	60	3
2950	2	4	4	5	5	60	14/16	23½	25½	60	5½	60	3
3230	2	4¼	4	5¼	5	60	14/16	23½	25½	60	5½	60	3½
3510	2	4½	4	5½	5	75	15/16	34	36½	60	5½	60	3½
3790	2	4¾	4¼	6	5¼	90	15/16	40¾	43¾	60	5½	60	4
4040	2	5	4½	6¼	5½	90	1	46	49½	60	5½	60	4
4290	2	5¼	4¾	6½	6	90	1	46	49½	60	6	60	4½
4530	2	5½	5	7	6¼	105	1 1/16	60¾	65	60	6	60	4½
4770	2	5¾	5¼	7¼	6½	105	1 1/16	60¾	65	60	6	60	5
5010	2	6	5½	7½	7	120	1 2/16	77¾	83½	60	6	60	5
5260	2	6¼	5¾	7¾	7¼	120	1 2/16	77¾	83½	60	6	60	5
5570	2	6½	6	8	7½	120	1 2/16	77¾	83½	60	6	60	5
5900	2	6¾	6¼	8½	7¾	120	1 3/16	87	93¼	60	7	60	5
6200	2	7	6½	8¾	8	120	1 3/16	87	93¼	60	7	60	5½
6560	2	7¼	6¾	9	8½	135	1 3/16	97¾	104¾	60	7	60	5½
6890	2	7½	7	9½	8¾	135	1 3/16	97¾	104¾	60	7	60	5½
7220	2	7¾	7¼	9¾	9	150	1 3/16	108½	116¼	60	7	60	5½
7550	2	8	7½	10	9½	150	1 4/16	120	128¾	60	7	60	5½
7900	2	8½	8	10½	10	150	1 4/16	120	128¾	60	7	60	5½
8250	2	9	8½	11¼	10¾	165	1 4/16	132	141½	60	7	60	5½
8600	3	9¾	9¼	12	11½	165	1 5/16	145¾	155¼	60	7	60	5½
8950	3	10½	9¾	13	12¼	180	1 5/16	159	169½	60	7	60	5½
9300	3	11¼	10½	14	13¼	180	1 6/16	174	186	60	7	60	5½
9650	3	12	11½	15	14¼	180	1 6/16	174	186	60	7	60	5½
10000	3	13	12½	16¼	15½	195	1 6/16	188½	201½	60	7	60	5½
10350	3	14	13¼	17½	16½	195	1 6/16	188½	201½	90	7	90	5½
10700	3	15	14¼	18¾	17¾	210	1 6/16	203	217	90	7	90	5½
11050	3	16	15¼	20	19	210	1 7/16	222¼	238	90	7	90	5½

* Where the equipment numeral lies between any two consecutive numbers given in the Table the equipment is to be governed by the greater.

TABLE 55

RENEWAL OF CHAIN CABLES WHEN WORN.

When any length of a Chain Cable is so worn that the mean diameter at its most worn part is reduced to the size given in the following Table, it is to be renewed.

ORIGINAL DIAMETER OF CHAIN CABLE.	MEAN DIAMETER REQUIRING RENEWAL OF CHAIN CABLE.	ORIGINAL DIAMETER OF CHAIN CABLE.	MEAN DIAMETER REQUIRING RENEWAL OF CHAIN CABLE.	ORIGINAL DIAMETER OF CHAIN CABLE.	MEAN DIAMETER REQUIRING RENEWAL OF CHAIN CABLE.	ORIGINAL DIAMETER OF CHAIN CABLE.	MEAN DIAMETER REQUIRING RENEWAL OF CHAIN CABLE.
Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
$\frac{11}{16}$	$\frac{10}{16}$	$1\frac{4}{16}$	$1\frac{2}{16}$	$1\frac{13}{16}$	$1\frac{10}{16}$	$2\frac{6}{16}$	$2\frac{2}{16}$
$\frac{12}{16}$	$\frac{21}{32}$	$1\frac{5}{16}$	$1\frac{3}{16}$	$1\frac{14}{16}$	$1\frac{11}{16}$	$2\frac{7}{16}$	$2\frac{3}{16}$
$\frac{13}{16}$	$\frac{23}{32}$	$1\frac{6}{16}$	$1\frac{7}{32}$	$1\frac{15}{16}$	$1\frac{23}{32}$	$2\frac{8}{16}$	$2\frac{4}{16}$
$\frac{14}{16}$	$\frac{25}{32}$	$1\frac{7}{16}$	$1\frac{9}{32}$	2	$1\frac{25}{32}$	$2\frac{9}{16}$	$2\frac{9}{32}$
$\frac{15}{16}$	$\frac{27}{32}$	$1\frac{8}{16}$	$1\frac{11}{32}$	$2\frac{1}{16}$	$1\frac{27}{32}$	$2\frac{10}{16}$	$2\frac{11}{32}$
1	$\frac{29}{32}$	$1\frac{9}{16}$	$1\frac{13}{32}$	$2\frac{2}{16}$	$1\frac{29}{32}$	$2\frac{11}{16}$	$2\frac{13}{32}$
$1\frac{1}{16}$	$\frac{15}{16}$	$1\frac{10}{16}$	$1\frac{15}{32}$	$2\frac{3}{16}$	$1\frac{31}{32}$	$2\frac{12}{16}$	$2\frac{15}{32}$
$1\frac{2}{16}$	1	$1\frac{11}{16}$	$1\frac{8}{16}$	$2\frac{4}{16}$	2	$2\frac{13}{16}$	$2\frac{17}{32}$
$1\frac{3}{16}$	$1\frac{1}{16}$	$1\frac{12}{16}$	$1\frac{9}{16}$	$2\frac{5}{16}$	$2\frac{1}{16}$	$2\frac{14}{16}$	$2\frac{9}{16}$

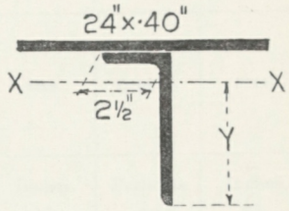
TABLE 56

(SEE CONTINUATION.)

GEOMETRICAL PROPERTIES OF SECTIONS.

A = Sectional Area of Angle in square inches.
I = Moment of Inertia about Neutral Axis XX in inch units.
$I/_Y$ = Modulus of Resistance of section in inch units.
} In conjunction with plating.

ANGLES HAVING 2½-IN. FLANGE.



Depth of Web in Inches.	Item.	Thickness of Web in Inches.										
		·20	·22	·24	·26	·28	·30	·32	·34	·36	·38	·40
2½	A	·96	1·05	1·14	1·23	1·32	1·41	1·50	1·58	1·67	1·76	1·84
	I	1·20	1·32	1·44	1·56	1·68	1·80	1·92	2·05	2·18	2·30	2·43
	$I/_Y$	·46	·50	·55	·60	·65	·70	·75	·80	·85	·90	·96
3	A	1·06	1·16	1·26	1·36	1·46	1·56	1·66	1·75	1·85	1·95	2·04
	I	2·03	2·26	2·49	2·60	2·80	3·00	3·20	3·40	3·60	3·80	4·00
	$I/_Y$	·66	·72	·78	·85	·92	·99	1·06	1·13	1·20	1·27	1·33
3½	A		1·27	1·38	1·49	1·60	1·71	1·82	1·92	2·03	2·14	2·24
	I		3·40	3·70	3·95	4·20	4·50	4·80	5·10	5·38	5·66	5·94
	$I/_Y$		·96	1·04	1·13	1·21	1·30	1·38	1·47	1·55	1·63	1·72

Depth of Web in Inches.	Item.	Thickness of Web in Inches.										
		·42	·44	·46	·48	·50	·52	·54	·56	·58	·60	·62
2½	A	1·92	2·01	2·09	2·17	2·25	2·33	2·41				
	I	2·56	2·68	2·80	2·92	3·04	3·15	3·26				
	$I/_Y$	1·01	1·06	1·11	1·16	1·21	1·26	1·30				
3	A	2·13	2·23	2·32	2·41	2·50	2·59	2·68	2·77	2·85		
	I	4·20	4·40	4·59	4·75	4·90	5·05	5·21	5·36	5·51		
	$I/_Y$	1·39	1·45	1·51	1·59	1·63	1·69	1·76	1·83	1·90		
3½	A	2·34	2·45	2·55	2·65	2·75	2·85	2·95	3·05	3·14	3·24	
	I	6·22	6·50	6·78	7·05	7·32	7·56	7·80	8·10	8·40	8·60	
	$I/_Y$	1·81	1·90	1·99	2·07	2·16	2·24	2·32	2·41	2·50	2·58	

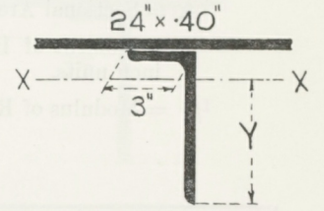
TABLE 56

(SEE CONTINUATION.)

GEOMETRICAL PROPERTIES OF SECTIONS.

A = Sectional Area of Angle in square inches.
I = Moment of Inertia about Neutral Axis XX in inch units.
$I/_Y$ = Modulus of Resistance of section in inch units.
} In conjunction with plating.

ANGLES HAVING 3-IN. FLANGE.



Depth of Web in Inches.	Item.	Thickness of Web in Inches.										
		·26	·28	·30	·32	·34	·36	·38	·40	·42	·44	·46
3	A	1·49	1·60	1·71	1·82	1·92	2·03	2·14	2·24	2·34	2·45	2·55
	I	2·60	2·80	3·00	3·20	3·40	3·60	3·80	4·00	4·20	4·40	4·60
	$I/_Y$	·85	·92	·99	1·06	1·13	1·20	1·27	1·33	1·39	1·45	1·51
3½	A	1·62	1·74	1·86	1·98	2·09	2·21	2·33	2·44	2·55	2·67	2·78
	I	4·00	4·20	4·50	4·80	5·10	5·40	5·70	6·00	6·30	6·60	6·90
	$I/_Y$	1·14	1·22	1·30	1·38	1·47	1·56	1·65	1·73	1·82	1·92	2·02
4	A	1·75	1·88	2·01	2·14	2·26	2·39	2·52	2·64	2·76	2·89	3·01
	I	5·80	6·20	6·60	7·00	7·40	7·80	8·20	8·60	9·00	9·40	9·80
	$I/_Y$	1·45	1·56	1·67	1·78	1·89	2·00	2·10	2·20	2·30	2·40	2·52
5	A	2·01	2·16	2·31	2·46	2·60	2·75	2·90	3·04	3·18	3·33	3·47
	I	9·75	11·00	12·25	13·00	13·75	14·50	15·20	15·90	16·60	17·30	18·00
	$I/_Y$	2·00	2·27	2·55	2·70	2·86	3·01	3·16	3·32	3·48	3·64	3·80
6	A	2·27	2·44	2·61	2·78	2·94	3·11	3·28	3·44	3·60	3·77	3·93
	I	18·70	19·90	21·00	22·10	23·20	24·30	25·40	26·50	27·60	28·70	29·80
	$I/_Y$	3·26	3·47	3·68	3·89	4·09	4·31	4·53	4·75	4·98	5·20	5·42

Depth of Web in Inches.	Item.	Thickness of Web in Inches.											
		·48	·50	·52	·54	·56	·58	·60	·62	·64	·66	·68	·70
3	A	2·65	2·75	2·85	2·95	3·05	3·14						
	I	4·80	4·90	5·10	5·25	5·40	5·60						
	$I/_Y$	1·59	1·63	1·69	1·76	1·83	1·90						
3½	A	2·89	3·00	3·11	3·22	3·33	3·43	3·54					
	I	7·20	7·40	7·60	7·80	8·20	8·40	8·60					
	$I/_Y$	2·10	2·17	2·24	2·32	2·41	2·50	2·58					
4	A	3·13	3·25	3·37	3·49	3·61	3·72	3·84	3·96				
	I	10·20	10·50	10·90	11·30	11·70	12·00	12·30	12·60				
	$I/_Y$	2·63	2·74	2·85	2·96	3·07	3·17	3·28	3·39				
5	A	3·61	3·75	3·89	4·03	4·17	4·30	4·44	4·58	4·71	4·84		
	I	18·70	19·30	20·00	20·70	21·30	22·00	22·70	23·30	24·00	24·60		
	$I/_Y$	3·96	4·12	4·28	4·45	4·61	4·77	4·93	5·09	5·25	5·41		
6	A	4·09	4·25	4·41	4·57	4·73	4·88	5·04	5·20	5·35	5·50	5·66	5·81
	I	30·90	32·00	33·10	34·20	35·30	36·40	37·40	38·40	39·40	40·40	41·40	42·40
	$I/_Y$	5·63	5·86	6·08	6·30	6·51	6·72	6·94	7·16	7·38	7·60	7·81	8·03

TABLE 56

(SEE CONTINUATION.)

GEOMETRICAL PROPERTIES OF SECTIONS.

ANGLES HAVING

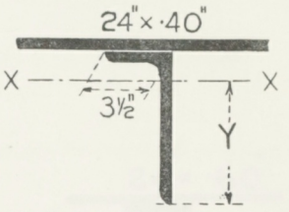
A = Sectional Area of Angle in square inches.
I = Moment of Inertia about Neutral Axis XX in inch units.
I/Y = Modulus of Resistance of section in inch units.
} In conjunction with plating.

Depth of Web in Inches.	Item.	Thickness of Web in Inches.											
		·26	·28	·30	·32	·34	·36	·38	·40	·42	·44	·46	·48
$3\frac{1}{2}$	A	1·75	1·88	2·01	2·14	2·26	2·39	2·52	2·64	2·76	2·89	3·01	3·13
	I	3·7	4·0	4·3	4·6	4·9	5·1	5·3	5·6	5·9	6·2	6·5	6·8
	I/Y	1·04	1·13	1·22	1·31	1·40	1·48	1·56	1·65	1·73	1·82	1·91	2·00
4	A	1·88	2·02	2·16	2·30	2·43	2·57	2·71	2·84	2·97	3·11	3·24	3·37
	I	6·0	6·3	6·7	7·0	7·4	7·8	8·2	8·6	9·0	9·4	9·8	10·2
	I/Y	1·46	1·56	1·66	1·76	1·87	1·98	2·09	2·20	2·30	2·41	2·52	2·63
5	A	2·14	2·30	2·46	2·62	2·77	2·93	3·09	3·24	3·39	3·55	3·70	3·85
	I	10·6	11·4	12·2	13·0	13·7	14·4	15·1	15·8	16·5	17·2	18·0	18·7
	I/Y	2·25	2·40	2·55	2·70	2·87	3·03	3·19	3·35	3·51	3·68	3·84	4·00
6	A			2·76	2·94	3·11	3·29	3·47	3·64	3·81	3·99	4·16	4·33
	I			20·4	21·6	22·8	24·0	25·2	26·4	27·6	28·8	29·9	31·0
	I/Y			3·58	3·82	4·04	4·27	4·50	4·72	4·95	5·18	5·40	5·62
7	A					3·45	3·65	3·85	4·04	4·23	4·43	4·62	4·81
	I					35·5	37·2	38·9	40·6	42·3	44·0	45·7	47·4
	I/Y					5·44	5·74	6·04	6·34	6·64	6·94	7·24	7·53

TABLE 56
(SEE CONTINUATION.)

GEOMETRICAL PROPERTIES OF SECTIONS.

3½-IN. FLANGE.



THICKNESS OF WEB IN INCHES.												Item.	Depth of Web in Inches.
·50	·52	·54	·56	·58	·60	·62	·64	·66	·68	·70	·72	·74		
3·25	3·37	3·49	3·61	3·72	3·84	3·96	4·07						A	3½
7·1	7·3	7·6	7·9	8·1	8·4	8·7	9·0						I	
2·09	2·18	2·26	2·34	2·42	2·50	2·59	2·70						I/Y	
3·50	3·63	3·76	3·89	4·01	4·14	4·27	4·39	4·51					A	4
10·6	10·9	11·2	11·6	12·0	12·3	12·6	13·0	13·4					I	
2·74	2·85	2·95	3·06	3·17	3·28	3·39	3·50	3·61					I/Y	
4·00	4·15	4·30	4·45	4·59	4·74	4·89	5·03	5·17	5·32	5·46			A	5
19·4	20·0	20·6	21·3	22·0	22·6	23·2	23·8	24·4	25·0	25·6			I	
4·15	4·32	4·48	4·64	4·80	4·95	5·12	5·28	5·44	5·60	5·68			I/Y	
4·50	4·67	4·84	5·01	5·17	5·34	5·51	5·67	5·83	6·00	6·16	6·32	6·48	A	6
32·1	33·2	34·2	35·3	36·3	37·4	38·4	39·4	40·4	41·4	42·3	43·2	44·1	I	
5·84	6·06	6·28	6·50	6·72	6·94	7·16	7·38	7·60	7·82	8·04	8·25	8·46	I/Y	
5·00	5·19	5·38	5·57	5·75	5·94	6·13	6·31	6·49	6·68	6·86	7·04	7·22	A	7
49·1	50·7	52·3	53·9	55·5	57·0	58·5	60·0	61·5	63·0	64·5	65·9	67·2	I	
7·82	8·11	8·40	8·69	8·98	9·26	9·55	9·84	10·13	10·41	10·70	10·98	11·25	I/Y	

TABLE 56

(SEE CONTINUATION.)

GEOMETRICAL PROPERTIES OF SECTIONS.

A = Sectional Area of Bulb Angles in square inches.

I = Moment of Inertia about Neutral Axis XX in inch units. } In conjunction with plating.

$I/_Y$ = Modulus of Resistance of section in inch units. }

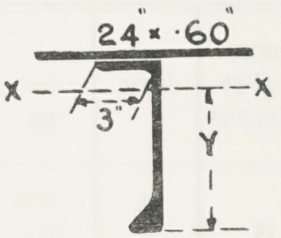
BULB ANGLES

Depth of Web in Inches.	Item.	Thickness of Web in Inches.										
		·28	·30	·32	·34	·36	·38	·40	·42	·44	·46	·48
5	A	2·52	2·66	2·79	2·92	3·06	3·19	3·32	3·45	3·59	3·72	3·85
	I	19·8	20·7	21·5	22·4	23·4	24·4	25·3	26·3	27·3	28·3	29·3
	$I/_Y$	4·00	4·20	4·40	4·55	4·75	4·95	5·15	5·35	5·55	5·75	6·00
5½	A		2·88	3·02	3·16	3·31	3·45	3·59	3·72	3·86	4·00	4·15
	I		27·7	28·8	29·9	31·0	32·2	33·4	34·5	35·7	36·9	38·1
	$I/_Y$		5·15	5·40	5·60	5·80	6·05	6·25	6·50	6·70	6·95	7·20
6	A		3·12	3·27	3·42	3·58	3·73	3·88	4·03	4·18	4·33	4·48
	I		36·1	37·5	39·0	40·5	42·1	43·7	45·3	46·8	48·3	49·8
	$I/_Y$		6·25	6·50	6·80	7·10	7·35	7·65	7·90	8·20	8·45	8·75
7	A				3·96	4·13	4·30	4·47	4·64	4·81	4·99	5·16
	I				62·7	64·7	66·7	68·8	70·9	73·0	75·2	77·5
	$I/_Y$				9·60	9·95	10·25	10·60	10·95	11·30	11·65	12·05
8	A					4·68	4·88	5·07	5·26	5·45	5·64	5·83
	I					97·7	100·5	103·4	106·5	109·6	112·6	115·8
	$I/_Y$					13·45	13·85	14·30	14·75	15·20	15·65	16·10

TABLE 56
(SEE CONTINUATION.)

GEOMETRICAL PROPERTIES OF SECTIONS.

HAVING 3-IN. FLANGE.



THICKNESS OF WEB IN INCHES.											Item.	Depth of Web in Inches.
·50	·52	·54	·56	·58	·60	·62	·64	·66	·68	·70		
3·99	4·12	4·25	4·38								A	5
30·2	31·2	32·2	33·1								I	
6·20	6·40	6·60	6·80								I/Y	
4·29	4·43	4·57	4·71								A	5½
39·4	40·6	41·9	43·4								I	
7·45	7·70	7·95	8·20								I/Y	
4·63	4·78	4·94	5·09	5·24							A	6
51·2	52·8	54·3	55·8	57·2							I	
9·00	9·30	9·60	9·85	10·10							I/Y	
5·33	5·50	5·67	5·84	6·02	6·19						A	7
79·8	82·0	84·2	86·4	88·5	90·6						I	
12·40	12·80	13·15	13·50	13·85	14·20						I/Y	
6·02	6·21	6·40	6·60	6·79	6·98	7·17					A	8
119·0	122·0	125·0	128·0	130·9	133·7	136·5					I	
16·60	17·10	17·55	18·00	18·45	18·90	19·30					I/Y	

TABLE 56
(SEE CONTINUATION.)

GEOMETRICAL PROPERTIES OF SECTIONS.

BULB ANGLES

A = Sectional Area of Bulb Angles in square inches.
I = Moment of Inertia about Neutral Axis XX in inch units. } In conjunction with plating.
$I/_Y$ = Modulus of Resistance of section in inch units. }

Depth of Web in Inches.	Item.	Thickness of Web in Inches.											
		·30	·32	·34	·36	·38	·40	·42	·44	·46	·48	·50	·52	·54
6	A	3·29	3·45	3·60	3·76	3·98	4·07	4·23	4·39	4·55	4·70	4·86	5·02	5·18
	I	36·5	37·9	39·3	40·8	42·3	43·8	45·4	46·9	48·4	49·9	51·4	52·9	54·4
	$I/_Y$	6·35	6·60	6·85	7·10	7·40	7·65	7·95	8·20	8·50	8·80	9·05	9·35	9·65
7	A			4·15	4·32	4·50	4·68	4·86	5·03	5·21	5·39	5·56	5·74	5·92
	I			62·8	64·9	66·9	69·0	71·1	73·2	75·4	77·7	80·0	82·3	84·6
	$I/_Y$			9·65	9·95	10·25	10·60	10·95	11·30	11·65	12·05	12·45	12·80	13·20
8	A				4·89	5·08	5·28	5·47	5·67	5·86	6·05	6·25	6·44	6·64
	I				98·0	100·9	103·9	107·0	110·1	113·2	116·4	119·5	122·5	125·4
	$I/_Y$				13·45	13·85	14·35	14·80	15·25	15·75	16·20	16·70	17·15	17·60
9	A					5·70	5·92	6·13	6·35	6·57	6·78	7·00	7·22	7·43
	I					148·0	151·5	155·0	159·0	163·0	167·0	171·0	175·0	179·0
	$I/_Y$					18·40	18·90	19·40	19·90	20·50	21·05	21·60	22·20	22·70
10	A						6·57	6·80	7·04	7·28	7·51	7·75	7·98	8·22
	I						211·0	215·5	220·5	225·5	230·5	235·5	240·5	246·0
	$I/_Y$						24·20	24·80	25·45	26·10	26·80	27·40	28·10	28·80
11	A							7·50	7·76	8·02	8·28	8·53	8·79	9·05
	I							286·4	292·0	298·1	304·2	310·3	316·6	323·2
	$I/_Y$							30·80	31·55	32·30	33·05	33·80	34·55	35·40
12	A								8·50	8·77	9·05	9·33	9·61	9·89
	I								382·0	389·0	396·1	403·8	411·5	419·5
	$I/_Y$								38·65	39·45	40·30	41·20	42·10	43·05

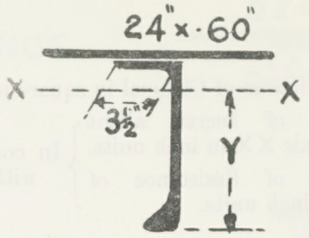
BULB ANGLES

13½	A									10·22	10·54	10·84	11·15	11·47
	I									564·6	572·0	580·0	588·8	598·4
	$I/_Y$									52·40	53·30	54·20	55·25	56·30

GEOMETRICAL PROPERTIES OF SECTIONS.

TABLE 56
(SEE CONTINUATION.)

HAVING $3\frac{1}{2}$-IN. FLANGE.



THICKNESS OF WEB IN INCHES.												ITEM.	DEPTH OF WEB IN INCHES.
·56	·58	·60	·62	·64	·66	·68	·70	·72	·74	·76	·78		
5·34	5·49	5·65	5·81									A	6
55·9	57·3	58·7	60·0									I	
9·90	10·15	10·40	10·65									I/Y	
6·09	6·27	6·45	6·62	6·80								A	7
86·8	88·9	91·0	93·2	95·3								I	
13·55	13·95	14·30	14·65	15·00								I/Y	
6·83	7·03	7·23	7·42	7·62	7·81							A	8
128·3	131·1	133·9	136·8	139·6	142·4							I	
18·05	18·50	18·90	19·35	19·75	20·20							I/Y	
7·65	7·87	8·08	8·30	8·52	8·73	8·95						A	9
183·0	187·0	191·0	195·0	199·0	203·0	207·0						I	
23·30	23·85	24·45	25·00	25·6	26·15	26·70						I/Y	
8·46	8·69	8·92	9·16	9·40	9·64	9·88	10·12	10·35				A	10
251·0	256·0	261·0	266·0	271·0	276·0	281·0	286·0	291·0				I	
29·45	30·10	30·80	31·45	32·10	32·80	33·50	34·20	34·80				I/Y	
9·31	9·56	9·82	10·07	10·33	10·59	10·84	11·09	11·35	11·60			A	11
329·7	336·2	342·6	349·0	355·3	361·4	367·5	373·4	379·3	385·0			I	
36·20	37·00	37·80	38·60	39·40	40·20	40·95	41·70	42·45	43·20			I/Y	
10·17	10·44	10·72	10·99	11·27	11·55	11·83	12·10	12·38	12·65	12·93		A	12
427·5	435·5	443·5	451·2	458·9	466·4	473·7	481·0	488·2	495·1	501·9		I	
44·00	44·95	45·90	46·85	47·75	48·65	49·55	50·45	51·30	52·15	53·00		I/Y	

HAVING 4-IN. FLANGE.

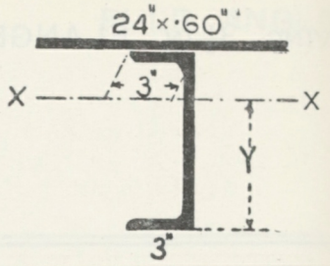
11·78	12·09	12·41	12·72	13·03	13·34	13·65	13·96	14·28	14·59	14·90	15·21	A	$13\frac{1}{2}$
608·5	618·5	628·5	639·0	650·0	660·5	671·0	681·0	691·0	701·0	710·5	720·0	I	
57·40	58·50	59·60	60·80	61·95	63·15	64·30	64·65	66·50	67·60	68·70	69·80	I/Y	

TABLE 56

(SEE CONTINUATION.)

GEOMETRICAL PROPERTIES OF SECTIONS.

CHANNELS HAVING 3-IN. FLANGE.



A = Sectional Area of Channel in square inches.
I = Moment of Inertia about Neutral Axis XX in inch units.
$I/_Y$ = Modulus of Resistance of section in inch units.
} In conjunction with plating.

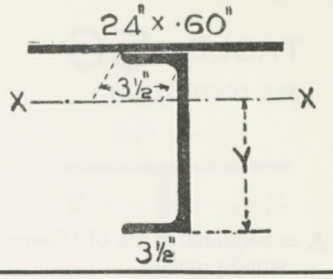
Depth of Web in Inches.	Thickness of Flange in Inches.	Item.	Thickness of Web in Inches.												
			·24	·26	·28	·30	·32	·34	·36	·38	·40	·42	·44	·46	·48
6	·38	A	3·59	3·71	3·83	3·95	4·07	4·19	4·31	4·43	4·55	4·67	4·79	4·91	5·03
		I	52·4	53·6	54·8	55·9	57·1	58·3	59·4	60·5	61·6	62·7	63·8	64·9	66·0
		$I/_Y$	9·25	9·50	9·75	10·0	10·25	10·5	10·75	10·95	11·2	11·4	11·65	11·9	12·1
7	·42	A		4·18	4·32	4·46	4·60	4·74	4·88	5·02	5·16	5·30	5·44	5·58	5·72
		I		79·5	81·3	83·1	84·8	86·5	88·2	89·9	91·6	93·3	95·0	96·6	98·2
		$I/_Y$		12·35	12·65	13·0	13·3	13·6	13·9	14·25	14·55	14·85	15·2	15·5	15·8
8	·44	A			4·69	4·85	5·01	5·17	5·33	5·49	5·65	5·81	5·97	6·13	6·29
		I			112·2	114·7	117·2	119·7	122·1	124·5	126·9	129·3	131·6	133·9	136·2
		$I/_Y$			15·5	15·9	16·3	16·7	17·1	17·5	17·9	18·3	18·7	19·1	19·5
9	·44	A				5·14	5·32	5·50	5·68	5·86	6·04	6·22	6·40	6·58	6·76
		I				149·7	153·1	156·5	159·9	163·3	166·7	170·0	173·2	176·4	179·5
		$I/_Y$				18·6	19·15	19·65	20·15	20·65	21·15	21·65	22·15	22·65	23·15
10	·45	A					5·67	5·87	6·07	6·27	6·47	6·67	6·87	7·07	7·27
		I					197·0	201·5	206·0	210·4	214·8	219·1	223·3	227·5	231·7
		$I/_Y$					22·4	23·0	23·6	24·2	24·8	25·4	26·0	26·6	27·2

Depth of Web in Inches.	Thickness of Flange in Inches.	Item.	Thickness of Web in Inches.												
			·50	·52	·54	·56	·58	·60	·62	·64	·66	·68	·70	·72	·74
6	·38	A	5·15	5·27	5·39	5·51	5·63	5·75	5·87	5·99	6·11				
		I	67·1	68·2	69·3	70·4	71·4	72·4	73·4	74·4	75·4				
		$I/_Y$	12·35	12·6	12·85	13·05	13·3	13·5	13·75	13·95	14·15				
7	·42	A	5·86	6·00	6·14	6·28	6·42	6·56	6·70	6·84	6·98	7·12			
		I	99·8	101·4	103·0	104·6	106·1	107·6	109·1	110·6	112·1	113·6			
		$I/_Y$	16·1	16·4	16·7	17·05	17·35	17·6	17·9	18·2	18·55	18·85			
8	·44	A	6·45	6·61	6·77	6·93	7·09	7·25	7·41	7·57	7·73	7·89	8·05		
		I	138·5	140·8	143·0	145·2	147·4	149·6	151·8	154·0	156·1	158·2	160·3		
		$I/_Y$	19·9	20·3	20·65	21·05	21·4	21·8	22·2	22·6	22·95	23·35	23·7		
9	·44	A	6·94	7·12	7·30	7·48	7·66	7·84	8·02	8·20	8·38	8·56	8·74	8·92	
		I	182·6	185·7	188·7	191·7	194·7	197·7	200·6	203·5	206·4	209·3	212·1	214·9	
		$I/_Y$	23·6	24·1	24·55	25·0	25·5	26·0	26·45	26·9	27·35	27·85	28·3	28·75	
10	·45	A	7·47	7·67	7·87	8·07	8·27	8·47	8·67	8·87	9·07	9·27	9·47	9·67	9·87
		I	235·9	240·0	244·0	248·0	251·9	255·8	259·7	263·5	267·3	271·1	274·9	278·7	282·4
		$I/_Y$	27·8	28·35	28·95	29·5	30·1	30·65	31·25	31·8	32·4	33·0	33·5	34·05	34·6

GEOMETRICAL PROPERTIES OF SECTIONS.

TABLE 56
(SEE CONTINUATION.)

CHANNELS HAVING 3½-IN. FLANGE.



A = Sectional Area of Channel in square inches.
I = Moment of Inertia about Neutral Axis XX in inch units. } In conjunction with plating.
$I/_Y$ = Modulus of Resistance of section in inch units. }

Depth of Web in Inches.	Thickness of Flange in Inches.	Item.	Thickness of Web in Inches.											
			·26	·28	·30	·32	·34	·36	·38	·40	·42	·44	·46	·48	·50
6	·48	A	4·73	4·85	4·97	5·09	5·21	5·33	5·45	5·57	5·69	5·81	5·93	6·05	6·17
		I	67·4	68·4	69·4	70·5	71·5	72·6	73·6	74·7	75·7	76·8	77·8	78·9	79·9
		$I/_Y$	12·3	12·5	12·7	12·95	13·15	13·4	13·65	13·9	14·1	14·35	14·55	14·8	15·05
7	·50	A		5·24	5·38	5·52	5·66	5·80	5·94	6·08	6·22	6·36	6·50	6·64	6·78
		I		97·8	99·4	101·0	102·6	104·2	105·7	107·3	108·8	110·4	111·9	113·4	115·0
		$I/_Y$		15·55	15·85	16·15	16·45	16·8	17·1	17·4	17·7	18·0	18·3	18·6	18·9
8	·52	A				5·94	6·10	6·26	6·42	6·58	6·74	6·90	7·06	7·22	7·38
		I				138·3	140·6	142·9	145·2	147·5	149·7	151·9	154·1	156·3	158·4
		$I/_Y$				19·65	20·05	20·40	20·8	21·15	21·55	21·95	22·35	22·75	23·15
9	·54	A				6·37	6·55	6·73	6·91	7·09	7·27	7·45	7·63	7·81	7·99
		I				183·0	186·0	189·5	192·5	196·0	199·0	202·0	205·0	208·0	210·5
		$I/_Y$				22·35	23·85	24·35	24·85	25·35	25·85	26·35	26·85	27·3	27·8
10	·56	A					6·99	7·19	7·39	7·59	7·79	7·99	8·19	8·39	8·59
		I					240·0	244·0	248·0	252·0	256·0	260·0	264·0	268·0	272·0
		$I/_Y$					28·0	28·6	29·2	29·8	30·35	30·9	31·5	32·1	32·7
12	·50	A					7·31	7·55	7·79	8·03	8·27	8·51	8·75	8·99	9·23
		I					348·0	354·5	361·0	368·0	375·0	381·5	388·0	394·5	401·0
		$I/_Y$					34·1	35·0	35·8	36·6	37·5	38·3	39·1	39·9	40·8
12	·60	A						8·12	8·36	8·60	8·84	9·08	9·32	9·56	9·80
		I						381·0	387·5	394·0	400·5	407·0	413·5	420·0	426·0
		$I/_Y$						38·0	38·8	39·6	40·45	41·3	42·15	43·0	43·75

Depth of Web in Inches.	Thickness of Flange in Inches.	Item.	Thickness of Web in Inches.												
			·52	·54	·56	·58	·60	·62	·64	·66	·68	·70	·72	·74	·76
6	·48	A	6·29	6·41	6·53	6·65	6·77	6·89	7·01						
		I	81·0	82·1	83·2	84·3	85·4	86·6	87·7						
		$I/_Y$	15·3	15·55	15·8	16·0	16·25	16·5	16·75						
7	·50	A	6·92	7·06	7·20	7·34	7·48	7·62	7·76	7·90					
		I	116·5	118·0	119·5	121·0	122·4	123·8	125·2	126·6					
		$I/_Y$	19·2	19·5	19·8	20·1	20·4	20·7	21·0	21·3					
8	·52	A	7·54	7·70	7·86	8·02	8·18	8·34	8·50	8·66	8.82				
		I	160·5	162·6	164·7	166·8	168·9	170·9	172·9	174·9	176·9				
		$I/_Y$	23·45	23·85	24·25	24·7	25·05	25·4	25·8	26·2	26·5				
9	·54	A	8·17	8·35	8·53	8·71	8·89	9·07	9·25	9·43	9·61	9·79			
		I	213·5	216·5	219·5	222·5	225·0	228·0	230·5	233·5	236·0	239·0			
		$I/_Y$	28·25	28·7	29·2	29·7	30·15	30·6	31·05	31·5	32·0	32·5			
10	·56	A	8·79	8·99	9·19	9·39	9·59	9·79	9·99	10·19	10·39	10·59	10·79		
		I	276·0	280·0	284·0	288·0	291·5	295·0	298·5	302·0	305·5	309·0	312·0		
		$I/_Y$	33·3	33·9	34·5	35·1	35·65	36·2	36·75	37·3	37·85	38·4	38·9		
12	·50	A	9·47	9·71	9·95	10·19	10·43	10·67	10·91	11·15	11·39	11·63	11·87	12·11	12·35
		I	407·5	414·0	420·0	426·0	432·0	438·0	444·0	450·0	456·0	462·0	468·0	474·0	479·0
		$I/_Y$	41·6	42·4	43·2	44·0	44·8	45·6	46·25	47·1	47·9	48·7	49·5	50·25	51·0
12	·60	A	10·04	10·28	10·52	10·76	11·00	11·24	11·48	11·72	11·96	12·20	12·44	12·68	12·92
		I	432·0	438·0	444·0	450·0	456·0	462·0	468·0	474·0	480·0	486·0	491·5	497·0	502·5
		$I/_Y$	44·5	45·3	46·1	46·9	47·7	48·45	49·2	50·0	50·85	51·7	52·45	53·2	54·0

TABLE 56

(SEE CONTINUATION.)

GEOMETRICAL PROPERTIES OF SECTIONS.

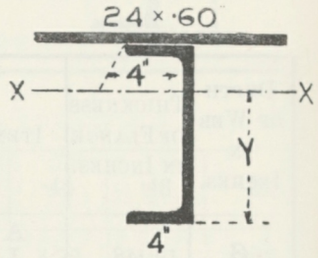
CHANNELS HAVING 4-IN. FLANGE

A = Sectional Area of Channel in square inches.

I = Moment of Inertia about Neutral Axis XX in inch units.

$I/_Y$ = Modulus of Resistance of section in inch units.

} In conjunction with plating.



Depth of Web in Inches.	Thickness of Flange in Inches.	Item.	Thickness of Web in Inches.									
			·38	·40	·42	·44	·46	·48	·50	·52	·54	·56
12	·60	A	8·97	9·21	9·45	9·69	9·93	10·17	10·41	10·65	10·89	11·13
		I	417·0	423·0	429·5	435·5	442·0	448·0	454·5	460·5	466·5	472·0
		$I/_Y$	42·20	43·00	43·80	44·60	45·40	46·20	47·00	47·80	48·60	49·40
15	·62	A		10·55	10·85	11·15	11·45	11·75	12·05	12·35	12·65	12·95
		I		716·5	728·0	739·5	751·0	762·5	773·5	784·5	795·0	806·0
		$I/_Y$		59·70	60·95	62·15	63·35	64·60	65·85	67·05	68·25	69·45
17	·68	A				12·36	12·70	13·04	13·38	13·72	14·06	14·40
		I				1020·5	1035·5	1050·5	1065·5	1080·5	1095·5	1110·0
		$I/_Y$				77·05	78·55	80·05	81·60	83·10	84·60	86·10

Depth of Web in Inches.	Thickness of Flange in Inches.	Item.	Thickness of Web in Inches.									
			·58	·60	·62	·64	·66	·68	·70	·72	·74	·76	·78
12	·60	A	11·37	11·61	11·85	12·09	12·33	12·57	12·81	13·05	13·29	13·53	13·77
		I	478·0	484·0	489·5	495·5	501·0	506·5	512·5	518·0	523·0	528·5	534·0
		$I/_Y$	50·20	51·00	51·80	52·60	53·35	54·15	54·90	55·65	56·45	57·20	57·95
15	·62	A	13·25	13·55	13·85	14·15	14·45	14·75	15·05	15·35	15·65	15·95	16·25
		I	816·5	827·5	837·5	848·0	858·0	868·0	878·5	888·0	898·0	908·0	917·5
		$I/_Y$	70·65	71·80	73·00	74·20	75·35	76·50	77·70	78·85	80·00	81·10	82·20
17	·68	A	14·74	15·08	15·42	15·76	16·10	16·44	16·78	17·12	17·46	17·80	18·14
		I	1125·0	1139·5	1154·0	1168·0	1182·5	1196·5	1210·5	1224·0	1237·5	1251·0	1264·5
		$I/_Y$	87·55	89·00	90·50	92·00	93·45	94·90	96·35	97·80	99·25	100·65	102·05

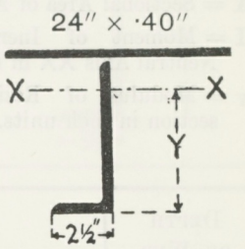
TABLE 56
(SEE CONTINUATION.)

GEOMETRICAL PROPERTIES OF SECTIONS.

INVERTED ANGLES

HAVING 2½-IN. FLANGE.

A = Sectional Area of Angle in square inches.
I = Moment of Inertia about Neutral Axis XX in inch units. } In conjunction with plating.
$^{I}/_{Y}$ = Modulus of Resistance of section in inch units. }



Depth of Web in Inches.	Item.	Thickness of Web in Inches.								
		·20	·22	·24	·26	·28	·30	·32	·34	·36
2½	A	·96	1·05	1·14	1·23	1·32	1·41	1·50	1·58	1·67
	I	4·2	4·5	4·9	5·2	5·5	5·8	6·0	6·3	6·5
	$^{I}/_{Y}$	1·7	1·8	2·0	2·1	2·2	2·3	2·5	2·6	2·7
3	A	1·06	1·16	1·26	1·36	1·46	1·56	1·66	1·75	1·85
	I	6·2	6·7	7·2	7·6	8·1	8·5	8·9	9·3	9·6
	$^{I}/_{Y}$	2·1	2·3	2·4	2·6	2·8	2·9	3·1	3·2	3·4
3½	A		1·27	1·38	1·49	1·60	1·71	1·82	1·92	2·03
	I		9·4	10·1	10·7	11·4	12·0	12·6	13·1	13·7
	$^{I}/_{Y}$		2·8	3·0	3·2	3·4	3·6	3·8	4·0	4·2

Depth of Web in Inches.	Item.	Thickness of Web in Inches.								
		·38	·40	·42	·44	·46	·48	·50	·52	·54
2½	A	1·76	1·84	1·92	2·01	2·09	2·17	2·25		
	I	6·8	7·0	7·2	7·4	7·6	7·8	7·9		
	$^{I}/_{Y}$	2·8	2·9	3·0	3·1	3·2	3·3	3·4		
3	A	1·95	2·04	2·13	2·23	2·32	2·41	2·50	2·59	2·68
	I	10·0	10·3	10·7	11·0	11·3	11·6	11·9	12·1	12·4
	$^{I}/_{Y}$	3·5	3·7	3·8	4·0	4·1	4·2	4·3	4·4	4·6
3½	A	2·14	2·24	2·34	2·45	2·55	2·65	2·75	2·85	2·95
	I	14·2	14·7	15·1	15·5	16·0	16·4	16·8	17·1	17·5
	$^{I}/_{Y}$	4·4	4·6	4·7	4·9	5·0	5·2	5·3	5·5	5·6

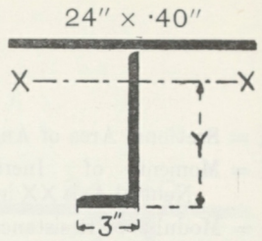
TABLE 56

(SEE CONTINUATION.)

GEOMETRICAL PROPERTIES OF SECTIONS.

INVERTED ANGLES

HAVING 3-IN. FLANGE.



A = Sectional Area of Angle in square inches.
I = Moment of Inertia about Neutral Axis XX in inch units. } In conjunction with plating.
$I/_Y$ = Modulus of Resistance of section in inch units. }

Depth of Web in Inches.	Item.	Thickness of Web in Inches.								
		·26	·28	·30	·32	·34	·36	·38	·40	·42
3	A	1·49	1·60	1·71	1·82	1·92	2·03	2·14	2·24	2·34
	I	8·6	9·1	9·6	10·0	10·5	10·9	11·3	11·7	12·1
	$I/_Y$	3·0	3·2	3·4	3·6	3·7	3·9	4·1	4·2	4·4
3½	A	1·62	1·74	1·86	1·98	2·09	2·21	2·33	2·44	2·55
	I	12·0	12·7	13·3	14·0	14·6	15·2	15·8	16·4	16·9
	$I/_Y$	3·6	3·9	4·1	4·3	4·5	4·7	5·0	5·2	5·4
4	A	1·75	1·88	2·01	2·14	2·26	2·39	2·52	2·64	2·76
	I	16·3	17·1	17·9	18·8	19·6	20·4	21·2	22·0	22·7
	$I/_Y$	4·4	4·6	4·9	5·1	5·4	5·6	5·9	6·1	6·4
5	A	2·01	2·16	2·31	2·46	2·60	2·75	2·90	3·04	3·18
	I	26·4	27·9	29·4	30·9	32·3	33·6	34·9	36·2	37·4
	$I/_Y$	5·7	6·1	6·5	6·9	7·3	7·6	8·0	8·3	8·7
6	A	2·27	2·44	2·61	2·78	2·94	3·11	3·28	3·44	3·60
	I	40·0	42·4	44·6	46·8	48·9	50·9	52·8	54·7	56·6
	$I/_Y$	7·4	7·9	8·4	8·9	9·3	9·8	10·3	10·7	11·1

Depth of Web in Inches.	Item.	Thickness of Web in Inches.								
		·44	·46	·48	·50	·52	·54	·56	·58	·60
3	A	2·45	2·55	2·65	2·75	2·85	2·95	3·05	3·14	
	I	12·4	12·8	13·1	13·4	13·7	14·0	14·3	14·6	
	$I/_Y$	4·6	4·7	4·9	5·0	5·2	5·3	5·4	5·5	
3½	A	2·67	2·78	2·89	3·00	3·11	3·22	3·33	3·43	3·54
	I	17·4	17·9	18·4	18·9	19·3	19·7	20·1	20·5	20·8
	$I/_Y$	5·6	5·8	6·0	6·1	6·3	6·5	6·6	6·8	6·9
4	A	2·89	3·01	3·13	3·25	3·37	3·49	3·61	3·72	3·84
	I	23·4	24·1	24·8	25·4	26·0	26·5	27·1	27·6	28·1
	$I/_Y$	6·6	6·9	7·1	7·3	7·6	7·8	8·0	8·2	8·4
5	A	3·33	3·47	3·61	3·75	3·89	4·03	4·17	4·30	4·44
	I	38·6	39·8	40·9	41·9	42·9	43·9	44·8	45·8	46·7
	$I/_Y$	9·0	9·3	9·6	9·9	10·2	10·5	10·8	11·1	11·3
6	A	3·77	3·93	4·09	4·25	4·41	4·57	4·73	4·88	5·04
	I	58·4	60·2	62·0	63·6	65·1	66·6	68·2	69·7	71·0
	$I/_Y$	11·6	12·0	12·4	12·8	13·2	13·6	14·0	14·4	14·7

GEOMETRICAL PROPERTIES OF SECTIONS.

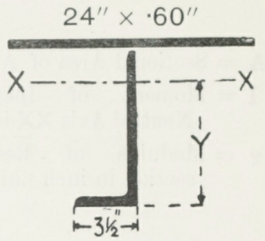
INVERTED ANGLES

HAVING $3\frac{1}{2}$-IN. FLANGE.

TABLE 56

(SEE CONTINUATION.)

A = Sectional Area of Angle in square inches.
I = Moment of Inertia about Neutral Axis XX in inch units. } In conjunction with plating.
I/Y = Modulus of Resistance of section in inch units. }



Depth of Web in Inches.	Item.	Thickness of Web in Inches.											
		·26	·28	·30	·32	·34	·36	·38	·40	·42	·44	·46	·48
$3\frac{1}{2}$	A	1·75	1·88	2·01	2·14	2·26	2·39	2·52	2·64	2·76	2·89	3·01	3·13
	I	15·2	16·1	16·9	17·8	18·6	19·3	20·1	20·9	21·6	22·3	22·9	23·6
	I/Y	4·4	4·6	4·9	5·2	5·4	5·7	5·9	6·2	6·4	6·7	6·9	7·1
4	A	1·88	2·02	2·16	2·30	2·43	2·57	2·71	2·84	2·97	3·11	3·24	3·37
	I	20·0	21·1	22·2	23·3	24·3	25·4	26·4	27·4	28·4	29·4	30·4	31·3
	I/Y	5·1	5·4	5·7	6·0	6·3	6·7	7·0	7·3	7·5	7·8	8·1	8·4
5	A	2·14	2·30	2·46	2·62	2·77	2·93	3·09	3·24	3·39	3·55	3·70	3·85
	I	32·3	34·2	36·0	37·9	39·7	41·4	43·1	44·7	46·3	47·8	49·2	50·7
	I/Y	6·7	7·2	7·6	8·0	8·5	8·9	9·3	9·7	10·1	10·5	10·8	11·2
6	A			2·76	2·94	3·11	3·29	3·47	3·64	3·81	3·99	4·16	4·33
	I			54·3	57·0	59·6	62·2	64·6	67·0	69·3	71·6	73·9	76·1
	I/Y			9·7	10·2	10·7	11·2	11·8	12·3	12·8	13·3	13·8	14·3
7	A					3·45	3·65	3·85	4·04	4·23	4·43	4·62	4·81
	I					84·3	88·0	91·5	95·0	98·5	101·7	105·0	108·1
	I/Y					13·3	13·9	14·6	15·3	15·9	16·5	17·2	17·8

Depth of Web in Inches.	Item.	Thickness of Web in Inches.											
		·50	·52	·54	·56	·58	·60	·62	·64	·66	·68	·70	·72	·74
$3\frac{1}{2}$	A	3·25	3·37	3·49	3·61	3·72	3·84	3·96	4·07					
	I	24·2	24·8	25·3	25·9	26·4	27·0	27·5	28·0					
	I/Y	7·3	7·6	7·8	8·0	8·2	8·4	8·6	8·8					
4	A	3·50	3·63	3·76	3·89	4·01	4·14	4·27	4·39	4·51				
	I	32·2	33·0	33·7	34·5	35·2	36·0	36·7	37·3	37·8				
	I/Y	8·7	8·9	9·2	9·5	9·7	9·9	10·1	10·4	10·6				
5	A	4·00	4·15	4·30	4·45	4·59	4·74	4·89	5·03	5·17	5·32	5·46		
	I	52·2	53·6	54·9	56·3	57·5	58·8	60·0	61·2	62·4	63·5	64·5		
	I/Y	11·6	12·0	12·3	12·7	13·0	13·3	13·7	14·0	14·4	14·7	15·0		
6	A	4·50	4·67	4·84	5·01	5·17	5·34	5·51	5·67	5·83	6·00	6·16	6·32	6·48
	I	78·3	80·5	82·5	84·5	86·5	88·4	90·3	92·0	93·7	95·4	97·1	98·6	100·2
	I/Y	14·8	15·3	15·7	16·2	16·7	17·1	17·6	18·0	18·4	18·8	19·2	19·6	20·0
7	A	5·00	5·19	5·38	5·57	5·75	5·94	6·13	6·31	6·49	6·68	6·86	7·04	7·22
	I	111·2	114·2	117·0	119·8	122·5	125·2	127·8	130·4	132·8	135·2	137·7	140·0	142·2
	I/Y	18·3	18·9	19·5	20·1	20·6	21·2	21·7	22·3	22·8	23·3	23·8	24·3	24·8

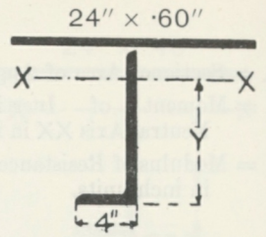
TABLE 56
(CONCLUDED.)

GEOMETRICAL PROPERTIES OF SECTIONS.

INVERTED ANGLES

HAVING 4-IN. FLANGE.

A = Sectional Area of Angle in square inches.
I = Moment of Inertia about Neutral Axis XX in inch units. } In conjunction with plating.
$I/_Y$ = Modulus of Resistance of section in inch units. }



Depth of Web in Inches.	Item.	Thickness of Web in Inches.												
		·30	·32	·34	·36	·38	·40	·42	·44	·46	·48	·50	·52	·54
4	A	2·31	2·46	2·60	2·75	2·90	3·04	3·18	3·33	3·47	3·61	3·75	3·89	4·03
	I	24·4	25·7	26·9	28·1	29·3	30·4	31·4	32·4	33·3	34·3	35·2	36·1	37·0
	$I/_Y$	6·4	6·7	7·1	7·4	7·8	8·1	8·4	8·7	9·0	9·3	9·6	9·9	10·2
5	A	2·61	2·78	2·94	3·11	3·28	3·44	3·60	3·77	3·93	4·09	4·25	4·41	4·57
	I	39·0	41·0	43·0	44·9	46·7	48·5	50·2	51·9	53·5	55·1	56·7	58·2	59·6
	$I/_Y$	8·3	8·8	9·2	9·7	10·1	10·6	11·0	11·5	11·9	12·3	12·7	13·2	13·6
6	A			3·38	3·47	3·66	3·84	4·02	4·21	4·39	4·57	4·75	4·93	5·11
	I			63·2	66·0	68·8	71·6	74·3	76·8	79·3	81·7	84·0	86·4	88·6
	$I/_Y$			11·5	12·1	12·7	13·3	13·8	14·4	15·0	15·5	16·1	16·6	17·1
8	A						4·64	4·86	5·09	5·31	5·53	5·75	5·97	6·19
	I						138·0	142·7	147·3	151·9	156·4	160·8	165·0	169·3
	$I/_Y$						19·8	20·6	21·4	22·2	23·0	23·8	24·6	25·4
9	A							5·28	5·53	5·77	6·01	6·25	6·49	6·73
	I							185·0	191·3	197·6	203·6	209·6	215·6	221·4
	$I/_Y$							24·1	25·1	26·1	27·1	28·1	29·0	30·0
10	A								5·97	6·23	6·49	6·75	7·01	7·27
	I								243·7	251·5	259·2	266·8	274·1	281·3
	$I/_Y$								29·1	30·2	31·3	32·4	33·6	34·7

Depth of Web in Inches.	Item.	Thickness of Web in Inches.												
		·56	·58	·60	·62	·64	·66	·68	·70	·72	·74	·76	·78	·80
4	A	4·17	4·30	4·44	4·58	4·71	4·84							
	I	37·9	38·7	39·6	40·4	41·3	42·1							
	$I/_Y$	10·5	10·8	11·1	11·4	11·7	12·0							
5	A	4·73	4·88	5·04	5·20	5·35	5·50	5·66	5·81					
	I	61·1	62·5	63·9	65·2	66·5	67·7	68·9	70·0					
	$I/_Y$	14·0	14·4	14·7	15·1	15·5	15·8	16·2	16·5					
6	A	5·29	5·46	5·64	5·82	5·99	6·16	6·34	6·51	6·68	6·85			
	I	90·7	92·8	94·8	96·8	98·7	100·6	102·4	104·1	105·8	107·5			
	$I/_Y$	17·6	18·1	18·6	19·1	19·6	20·0	20·5	20·9	21·3	21·8			
8	A	6·41	6·62	6·84	7·06	7·27	7·48	7·70	7·91	8·12	8·33	8·54	8·75	8·96
	I	173·5	177·5	181·5	185·3	189·0	192·6	196·2	199·6	202·9	206·0	209·0	212·0	214·8
	$I/_Y$	26·2	26·9	27·7	28·5	29·2	29·9	30·6	31·3	32·0	32·6	33·2	33·8	34·4
9	A	6·97	7·20	7·44	7·68	7·91	8·14	8·38	8·61	8·84	9·07	9·30	9·53	9·76
	I	226·9	232·2	237·5	242·5	247·5	252·2	256·8	261·3	265·7	270·0	274·3	278·5	282·7
	$I/_Y$	30·9	31·8	32·7	33·6	34·4	35·3	36·2	37·0	37·8	38·6	39·4	40·2	41·0
10	A	7·53	7·78	8·04	8·30	8·55	8·80	9·06	9·31	9·56	9·81	10·06	10·31	10·56
	I	288·4	295·3	302·0	308·7	315·3	321·6	327·8	333·8	339·6	345·1	350·3	355·3	360·0
	$I/_Y$	35·8	36·9	38·0	39·0	40·1	41·1	42·1	43·1	44·0	45·0	45·9	46·7	47·5

RULES FOR
PETROLEUM TANKERS

INDEX

CONSTRUCTION OF PETROLEUM TANKERS

A

	Section.	Clause.	Page.
Access Holes	49	6	204
After End	48	—	202
„ continuity of strength at ...	48	9	202
„ decks in machinery space	48	6	202
„ double bottom at	48	2	202
„ extent of longitudinal framing at	48	9	202
„ frames supported by stringers at	48	3	202
„ framing, transverse, at ...	48	3	202
„ longitudinal framing, extent of	48	9	202
„ oil fuel bunkers at... ...	48	7	202
„ pillars at	48	5	202
„ side stringers at	48	4	202
„ strong beams at	48	5	202
„ web frames at	48	4	202
After Peak	48	8	202
Air Holes	49	7	204
Angle, Stringer	44	1	199

B

Beams, strong	48	5	202
Bilge keel shell connections	43	3	199
„ longitudinals	42	1	199
Bottom, double, at after end	48	2	202
„ longitudinals	42	1	199
„ plating at fore end	47	3	201
„ structure at fore end ...	47	3	201
„ transverses	41	1	198
„ transverses, additional forward	47	3	201
Brackets	49	2	203
„ tripping	49	4	203
Bridge	45	1	200
„ end bulkheads	45	3	200
„ set in from ship's side ...	40	10	198
	45	1	200
„ side plating, arrangements at ends	45	2	200
Bulkheads	46	—	200
„ cofferdam	46	1	200
„ corrugated	46	5	201
„ forecastle	45	3	200
„ plating	46	2	200
„ poop	45	3	200
„ stiffener end connections	46	4	201
„ stiffener connections to webs and girders ...	46	4	201
„ stiffening	46	3	200
„ vertical webs and horizontal girders	46	3	200
„ vertical webs, end connections of	46	4	201
Bunkers, oil fuel	48	7	202
„ testing of	51	3	204
Buttress Brackets to lower girders & stringers	41	5	198

C

Casings, machinery	45	5	200
Centre Line Girders	41	7	198
Coamings	50	2	204
Cofferdam bulkheads	46	5	201
Cofferdams	40	5	197
Continuity of Strength at after end	48	9	202
„ „ at deck ...	44	3	199
„ „ at fore end ...	47	8	202
„ „ at shell ...	43	3	199
Covers, Hatch	50	3	204
Cross Ties	41	6	198

D

	Section.	Clause.	Page.
Decks	... 44	—	199
Deck, continuity of strength of	... 44	3	199
„ **Girders** at centre line ...	... 41	7	198
„ **Houses** amidships ...	... 40, 45	6, 1	197, 200
„ „ scantlings of ...	... 45	4	200
Decks in machinery space ...	... 48	6	202
Deck Longitudinals	... 42	1	199
Decks, lower at fore end ...	... 44	2	199
Deck Openings	... 44	3	199
„ Strength	... 44	1	199
„ Strength, definition of ...	... 40	10	198
„ **Transverses**	... 41	1	198
Deep Tank at fore end	... 47	—	201
„ „ **Frames**	... 47	4	201
„ „ intercostal girders in	... 47	3	201
„ „ **Side Stringers** ...	... 47	5	201
„ „ testing of	... 51	3	204
„ „ top	... 47	6	202
Definitions	... 40	10	198
Docking Girders	... 41	7	198
Double Bottom at after end ...	... 48	2	202
Drain Holes	... 49	7	204
Draught	... 40	10	198

E

End Attachments of Bulkhead Stiffeners	... 46	4	201
„ „ „ **Horizontal Girders on Bulkheads**	... 46	3	200
„ „ „ **Longitudinals**	... 42	1	199
„ „ „ **Primary Supporting Members**	... 49	2	203
„ „ „ **Side Frames**	... 42	2	199
„ „ „ **Vertical Webs on Bulkheads**	... 46	3	200
End Brackets, stiffening of ...	... 49	2	203
End Bulkheads of Superstructures	... 45	3	200
Ends of Lower Decks, arrangements at	44	3	199
Ends of Superstructures, arrangements at	... 45	2	200
Entrance to Pump Room	45	6	200
Equipment and Equipment Numeral ...	40	11	198

F

Face Plates, support of ...	... 49	4	203
Fastenings to Hatch Covers ...	... 50	3	204
Floors in Deep Tank	... 47	3	201
Foot Holes	49	6	204
Forecastle	40, 45	6, 1	197, 200
„ **Bulkheads**	45	3	200
Fore End	47	—	201
„ additional transverses in bottom at	47	3	201
„ bottom plating at	47	3	201
„ bottom structures at ...	47	3	201
„ continuity of strength at change of framing system	47	8	202
„ deep tank top at	47	6	202
„ floors in deep tank at ...	47	3	201
„ frame spacing at	47	2	201
„ hold frames above	47	4	201
„ intercostal side girders at...	47	3	201
„ side frames in deep tank ...	47	4	201
„ side stringers at	47	5	201
„ 'tween deck frames at ...	47	4	201
„ web frames at, scantlings and extent of	47	5	201
„ web frames at, end connections of	47	5	202
Fore Peak	47	7	202
Frames above deep tank	47	4	201
„ at after end	48	3	202
„ in 'tween deck forward ...	47	4	201
„ spacing at fore end	47	2	201
Freeing Arrangements	40	7	197
Front Bulkhead of Poop	45	3	200

G

Gangway	40	7	197
General Arrangement	40	3	197
Girders, centre line	41	7	198
„ horizontal on bulkheads ...	46	3	200
„ structural details of	49	1	203

H

Hatch Covers	50	3	204
Hatch Cover Fastenings	50	3	204
Hatchways	50	—	204
„ clear of oil	50	4	204
„ oil tight	50	1	204
Head, Rudder	40	8	197
„ test	51	2	204
Height of Superstructures	40	6	197
Hold Frames above deep tank	47	4	201

	Section.	Clause.	Page.
Holes, access	49	6	204
„ air	49	7	204
„ drain	49	7	204
„ foot and hand	49	6	204
„ lightening	49	6	204
Horizontal Girders on bulkheads ...	46	3	200
„ „ end connections ...	46	4	201
„ „ on longitudinal bulkheads ...	41	5	198
„ „ on transverse bulkheads ...	41	4	198

I

Inlets, sea	43	2	199
Intercostal Girders at centre line ...	41	7	198
„ **Side Girders** in deep tank...	47	3	201

L

Lateral Stability of primary supporting members	49	4	203
Length of Superstructures	40	6	197
Lightening Holes	49	6	204
Longitudinals and end connections ...	42	1	199
„ bilge	42	1	199
„ bottom	42	1	199
„ side	42	1	199
„ deck	42	1	199
Longitudinal Bulkheads, arrangements at ends of...	46	1	200
„ „ extent of oil tightness ...	46	1	200
„ „ horizontal girders on...	41	5	198
„ „ vertical webs on ...	41	3	198
Longitudinal Framing, extent of at after end	48	9	202
Long Tanks, bulkheads at ends of ...	46	1	200
Lower Decks	44	2	199
„ „ arrangements at ends of	44	3	199

M

Machinery Casings	45	5	200
„ **Space** (*see* after end) ...	48	—	202
Method of Construction	40	2	197
Midship Deckhouses	45	1	200
„ „ scantlings of ...	45	4	200
Minimum Thickness of Structure ...	49	8	204

N

Notches	49	5	204
Numeral for Equipment	40	11	198

O

Oil Fuel Bunkers at after end	48	7	202
Oiltight Bulkheads	46	—	200
„ „ arrangements at ends	46	1	200
„ „ extent of oiltightness	46	1	200
Oiltight Hatchways	50	1	204
Openings in deck	44	3	199
„ in shell	43	2	199

P

Pillars at after end	48	5	202
Plans, submission of	40	9	197
Plating, Shell	43	1	199
Poop	40	6	197
	45	1	200
„ front bulkhead	45	3	200
„ side plating, arrangements at fore end	45	2	200
„ side plating, increase at fore end	45	2	200
Primary Supporting Members, end attachments	49	2	203
Primary Supporting Members, structural details	49	—	203
Pump Room Entrances	45	6	200

Q

Quadrant	40	8	197

R

Riveted Construction	49	10	204
Rudder and Rudder Head	40	8	197

S

Scuppers	43	3	199
	44	3	199
Sea Inlets, arrangements at	43	2	199
„ „ compensation for	43	2	199
Sheerstrake, increase at ends of superstructures	45	2	200
„ scuppers in	43	3	199
„ upper edge of	43	3	199
„ welded fittings on ...	43	3	199

	Section.	Clause.	Page.
Shell, continuity of strength	43	3	199
„ openings in	43	2	199
„ plating	43	1	199
Side Frames, connections to girders ...	42	2	199
„ „ end connections of ...	42	2	199
„ „ in deep tank, forward ...	47	4	201
„ „ transverse	42	2	199
Side Girders, intercostal in deep tank	47	3	201
Side Longitudinals	42	1	199
Side Stringers	41	5	198
„ „ at after end	48	4	202
„ „ at fore end	47	5	201
Side Transverses	41	1	198
„ „ taper of	41	1	198
Spacing of Frames at fore end ...	47	2	201
„ **Transverses**, maximum ...	42	1	199
Steering Gear	40	8	197
Stiffening of bulkheads	46	3	200
„ of end brackets to primary members	49	2	203
„ of web plates of primary members	49	3	203
Strength Deck, definition of	40	10	198
„ „ extent of midship thickness	45	2	200
„ „ scantlings of	44	1	199
Stringer Angle, scantlings and extent	44	1	199
Stringers, details of	49	1	203
Stringer Plate, increases at ends of superstructures	45	2	200
Stringers, side	41	5	198
Strong Beams in machinery space ...	48	5	202
Structural Arrangements at fore end	47	—	201
„ **Design**	40	3	197
„ **Details**	49	—	203
Submission of Plans	40	9	197
Superstructures	40	6	197
	45	—	200
„ end bulkheads of ...	45	3	200
„ height and length of	40	6	197
„ scantlings of ...	45	1	200
„ strengthening at ends of	45	2	200

T

	Section.	Clause.	Page.
Tapered Side Transverses	41	1	198
Test Head	51	2	204
Testing	51	—	204
„ **Bunkers**	51	3	204
„ **Deep Tanks**	51	3	204
Thickness, minimum requirements ...	49	8	204
Ties, cross	41	6	198
Tillers	40	8	197
Transverses, additional at fore end ...	47	3	201
Transverses, bottom	41	1	198
Transverse Bulkheads at ends of long tanks	46	1	200
Transverse Bulkhead Horizontal Girders	41	4	198
Transverse Bulkhead Vertical Webs ...	41	4	198
Transverses, deck	41	1	198
„ details of	49	1	203
Transverse Framing at after end ...	48	3	202
Transverses, maximum spacing of ...	42	1	199
„ side	41	1	198
Transverse Side Frames	42	2	199
Tripping Brackets	49	4	203
'Tween Deck Frames at fore end ...	47	4	201

V

Vertical Webs on bulkheads	46	3	200
„ „ on bulkheads, end connections	46	4	201
„ „ on longitudinal bulkheads	41	3	198
	41	3	198
„ „ on transverse bulkheads	41	4	198

W

Web Frames at after end	48	4	202
„ „ at fore end	47	5	201
„ „ at fore end, end connections of... ...	47	5	202
	47	5	202
Web stiffening	49	3	203
Webs, structural details of	49	1	203
Welded Connections	49	9	204
„ **Fittings** on sheerstrake ...	43	3	199

coming into force 15th June 1950.

RULES FOR THE CONSTRUCTION OF PETROLEUM TANKERS.

NOTE: Sections 1 to 34 and Tables 1 to 56 are contained in the **Rules for the Construction of Steel Ships.**

Section 40.

GENERAL.

1. **Application.**—The **General Regulations for the Classification of Steel Ships** and the **Rules for the Construction of Steel Ships** apply to Petroleum Tankers except as otherwise required by the following Rules.

The scantlings and arrangements of Tankers for cargoes other than petroleum will be specially considered in relation to the nature, density and temperature of the cargo carried.

2. **Method of Construction.**—The Rules and Tables set forth requirements for welded construction with certain modifications when riveting is adopted. The **Rules for Electric Arc Welding in Ship Construction** are to be complied with where applicable. *See also* **Rules for Quality and Testing of Materials, Section 1, clause 13.**

3. **Structural Design.**—The Rules are intended for single deck Tankers having two longitudinal bulkheads, with the machinery aft, and framed in the cargo tank spaces either on the longitudinal system at bottom, sides, deck and longitudinal bulkheads, or alternatively, on the combined system with longitudinal framing at the bottom and deck, and transverse side framing and vertical stiffening on the longitudinal bulkheads.

Approval will be given for other systems of construction or arrangements if these are considered equivalent to the Rule requirements.

If the proportion of length to depth exceeds fourteen, or the ratio of breadth to depth is extreme, or the ratio of tank space to length of ship is abnormally low, specially increased scantlings will be required.

4. **Length of Tanks.**—If the length of any oil tank exceeds 35 feet the scantlings and arrangements of the boundary bulkheads will be specially considered.

5. **Cofferdams.**—Cofferdams are to be provided at the forward and after ends of the oil cargo spaces unless these are separated from the ends of the ship by a pump room; cofferdams are to be at least 3 feet in length and are to cover the whole area of the end bulkheads of the cargo spaces.

6. **Superstructures.**—A forecastle of not less than ·07L in length is to be fitted.

The machinery space is to be protected by a poop of sufficient length to cover the machinery casings, or, the poop may be dispensed with provided the machinery casings are protected by a deckhouse of equivalent strength.

The height of superstructures is to be at least 6 feet where L is 250 feet or less and 7 feet 6 inches where L is 400 feet or more, with intermediate values in proportion. *See also* **Section 45.**

7. **Freeing Arrangements and Gangway.**—Ships with bulwarks are to have open rails fitted for at least half the length of the exposed part of each well.

A strong, permanent fore and aft gangway is to be fitted at the level of the superstructure decks.

8. **Rudder.**—The diameter of the rudder head and of the pintles is to be increased by 10 per cent above the requirements of **Section 26.** The remaining scantlings of the rudder are to be based on the increased diameter of the rudder head; the quadrant, tiller and steering gear need not be similarly increased.

The requirements of **Section 10, clause 7,** for Navigation in Ice are to be applied only where they exceed the above increases.

9. **Submission of Plans.**—In addition to the plans required by **Section 1,** plans showing the construction of the transverse and longitudinal oiltight bulkheads, end

GREATER THAN ABOUT 1·9.

LESS THAN ·62 IN SHIPS GREATER THAN 450' IN LENGTH & LESS THAN ·42 IN SHIPS OF 450' IN LENGTH WOULD BE CONSIDERED ABNORMALLY LOW.

connections for all longitudinals and other framing members, the structure at the ends of the ship, deckhouses protecting machinery casings and arrangements at the junction of transverse and longitudinal framing are also to be submitted.

10. **Definitions.**—The **Draught d** for use in the Tables is to be the summer moulded draught corresponding to the minimum Tanker freeboard permitted for the dimensions of the ship.

In computing the freeboard for use in the Tables, a bridge set in not more than 12 inches from the ship's side may be taken into account.

The **Strength Deck** is the continuous deck irrespective of the superstructures above that deck.

11. **Equipment.**—Equipment is to be as required by **Section 33,** but for ships without sheer in way of ·5L amidships the Depth for the Equipment Numeral may be taken as 97½ per cent of the depth moulded amidships.

Section 41.

TRANSVERSES AND WEBS, STRINGERS AND GIRDERS.

1. **Bottom and Side Transverses.**—(*a*) The scantlings of bottom transverses are to be derived from **Table 60** and associated Notes.

(*b*) The scantlings of side transverses which support longitudinals or side stringers but which are not supported by cross-ties are to be derived from **Table 60** and associated Notes.

(*c*) The scantlings of side transverses which support longitudinals or side stringers but which are supported by cross-ties are to be derived from **Table 63** and associated Notes.

(*d*) If it is desired to taper side transverses the mean depth is to be derived from **Table 60** or **63** and associated Notes ; the increase in depth at the bottom and the decrease at the top is not to exceed 10 per cent of the mean depth.

(*e*) Side transverses are to be fitted in ships of 35 feet depth or over having the side shell and longitudinal bulkheads vertically framed where either the proportion B/D exceeds 1·75 or the spacing of the transverse bulkheads exceeds 32 feet.

2. **Deck Transverses.**—The scantlings of deck transverses are to be as required by **Table 61** and associated Notes.

3. **Vertical Webs on Longitudinal Bulkheads.**—The vertical webs on longitudinal bulkheads are to have the same scantlings as the transverses at the ship's side, but the thickness of the web plates may be reduced by 10 per cent. Vertical webs may also be tapered as permitted for side transverses. *See* **clause 1** (*d*) above.

4. **Vertical Webs and Horizontal Girders on Transverse Bulkheads.**—The scantlings of vertical webs and horizontal girders on transverse bulkheads are to be derived from **Table 64** and associated Notes.

5. **Side Stringers and Horizontal Girders.**—Side stringers for the support of transverse framing are to be fitted as required by **Table 69** and the scantlings are to be derived from **Table 64** and associated Notes. Horizontal girders are to be fitted at the same level to support the vertical stiffeners of the longitudinal bulkheads ; the scantlings of these girders are also to be derived from **Table 64** and associated Notes. In ships where webs are not fitted the lower side stringers and horizontal girders are to be supported by suitable buttress brackets from the bottom transverses.

6. **Cross Ties.**—Cross ties may be of plate or sectional material, but they are to be of such a form as to provide sufficient stiffness in all directions.

Scantlings are to be derived from **Table 66** and associated Notes.

Cross ties are to be connected to the vertical webs or to the horizontal girders by suitable brackets in order to spread the load.

7. **Centre Line Girders.**—(*a*) An intercostal girder effectively connected to the transverses and bulkheads, and having scantlings derived from **Table 62** and associated Notes, is to be fitted at the centre line to support the keel when docking. Flanged or otherwise stiffened brackets are to be fitted on both sides of the girder not more than 6 feet apart with intermediate vertical stiffeners, or equivalent arrangements are to be provided.

If the centre line girder is intended to support the bottom transverses, it is to be continuous between transverse bulkheads and to have scantlings derived from **Table 60** and associated Notes.

(*b*) A centre line girder is also to be fitted in association with the transverses under the deck. The girder is to be suitably stiffened and supported, and to have scantlings derived from **Table 65** and associated Notes.

For structural details and connections *see* **Section 49** and **Table 76.**

Section 42.

BOTTOM, SIDE AND DECK FRAMING.

1. **Bottom, Side and Deck Longitudinals.**—(*a*) The scantlings of bottom and deck longitudinals are to be derived from **Table 67** and associated Notes.

(*b*) The scantlings of side longitudinals are to be derived from **Table 68** and associated Notes.

(*c*) The scantlings of bilge longitudinals are to be graduated between those required for the bottom and side longitudinals.

(*d*) The spacing of transverses is not to exceed 12 feet and longitudinals are to be connected to them as required by **Table 76 (E)**.

(*e*) End connections of longitudinals to bulkheads are to provide adequate fixity and, so far as practicable, direct continuity of longitudinal strength.

2. **Transverse Side Frames in Cargo Tanks.**—(*a*) The scantlings of side frames are to be derived from **Table 69** and associated Notes.

(*b*) Side frames are to be connected to horizontal girders as required by **Table 76 (E)**.

(*c*) The brackets at the upper end of side frames are to be as shown in **Table 76 (F)**.

(*d*) Side frames are to be efficiently connected at the lower end to stiffened brackets covering the entire round of bilge and extending at least to the first bottom longitudinal. The thickness of the brackets is to be that required for the transverses in the wing tanks.

(*e*) Side frames are to be reinforced by side transverses where required by **Section 41, clause 1** (*e*).

Section 43.

SHELL PLATING.

1. **Scantlings.**—The thicknesses of the keel, shell plating and sheerstrake are to be derived from **Table 70** and associated Notes. *See also* **Section 47, clause 3** (*d*).

2. **Openings in Shell.**—Sea inlets in pump rooms are to be fitted, if practicable, clear of the bilge radius and arranged so as to avoid discontinuity of transverse frames, longitudinals or bilge keels.. The plating in way of the inlets is to be increased in thickness or doubled and if the openings are not circular or oval the corners are to be rounded with as large a radius as practicable.

3. **Continuity of Strength** is to be maintained at the break of the poop and at the ends of the bridge as required by **Section 45.** Effective stiffening and support to shell plating are to be provided in cofferdams and pump rooms.

The upper edge of the sheerstrake is to be dressed smooth and kept free of isolated welded fittings, connections, or scupper openings above the deck involving local discontinuities. Bilge keels and their shell connections are to be gradually tapered off at their ends and scalloped at their butts and at the butts of shell plating.

Section 44.

DECKS.

1. **Scantlings of Strength Deck.**—(*a*) The thickness of the Strength Deck stringer and plating and the scantlings of the stringer angle, if fitted, are to be derived from **Table 70** and associated Notes.

(*b*) The midship thicknesses are to be maintained for ·5L amidships, and scantlings in way of the fore end of the poop are to be as required by **Section 45, clause 2** (*a*) and (*b*). When the machinery opening extends forward beyond a point one third of the breadth B abaft the poop front, deck scantlings will be specially considered.

(*c*) The scantlings of stringer angles determined from **Table 70,** Col. 16 and Note 6 are to extend throughout the cargo spaces and at least one third of the breadth B within the poop. At the ends of the ship the scantlings of stringer angles are to be determined from **Table 19.**

2. **Scantlings of Lower Decks.**—The scantlings and arrangements of lower decks are to be as required by **Sections 11, 14** and **15.**

3. **Continuity of Strength.**—(*a*) The strength deck stringer plate is to be increased in thickness at the ends of superstructures as required by **Section 45, clause 2** (*a*).

(*b*) Abrupt discontinuities at the ends of lower decks and flats are to be avoided by suitable tapering of the stringer plates or by fitting large brackets.

(*c*) The corners of all deck openings are to be well rounded and smooth, and strength is to be maintained in way of pump room entrances or other openings.

(*d*) If the stringer angle is cut at the scuppers compensation is to be provided.

For the decks of superstructures *see* **Section 45, clause 1.**

Section 45.

SUPERSTRUCTURES.

1. **Scantlings.**—(*a*) The scantlings of the bridge and forecastle are to be as required by **Table 21** and associated Notes and the scantlings of the poop are to be as required for a bridge.

(*b*) When the side of the bridge is set in from the ship's side not more than 12 inches the scantlings are to be as required for a bridge.

(*c*) The scantlings of midship deckhouses are to be as required by **clause 4** below.

2. **Strengthening at Ends of Superstructures.**—(*a*) The thicknesses of the sheerstrake and strength deck stringer plate are to be increased by 20 per cent at the break of the poop and at the ends of the bridge, except that if the bridge does not extend to the ship's side the sheerstrake need not be increased.

(*b*) The midship thickness of the strength deck plating is to extend into the poop for a distance at least equal to one third of the breadth B.

(*c*) The thickness of the poop side plating is to be increased by 20 per cent at the fore end.

(*d*) The bridge and poop side plating is to be extended beyond the ends of these superstructures and tapered into the bulwark or sheerstrake; the extended plating is to be effectively supported. Where connections at these parts are welded arrangements are to be made to ensure an easy sweep and the absence of any local discontinuity at the junction with the main structure.

3. **End Bulkheads.**—(*a*) The bulkhead at the fore end of the poop is to have the scantlings required by **Table 22** and associated Notes, but if any part of the bulkhead forms the fore end of the machinery casing the stiffeners in way are to be spaced 24 inches apart and are to be bracketed at top and bottom or are to have equivalent end connections.

(*b*) Openings in the poop front are to have sills not less than 18 inches in height.

(*c*) The end bulkheads of the bridge and forecastle are to comply with the requirements of **Table 22** and associated Notes.

4. **Midship Deckhouses.**

(*a*) If a deckhouse is fitted on the strength deck amidships in place of a bridge, the scantlings are to be derived from **Table 23** as indicated below.

(*b*) The front bulkhead is to be plated and stiffened in accordance with the requirements for "Fronts of Long and Short Deckhouses", Lower Tier, Col. A, but the plating is to be increased in thickness by 10 per cent and the stiffeners are to be bracketed at top and bottom.

(*c*) The side and after bulkheads are to be plated in accordance with the requirements for "Sides of Long and Short Deckhouses", Lower Tier, Col. A, but the plating is to be increased in thickness by 10 per cent and the stiffeners are to be 60 per cent greater in modulus than required by the same column.

5. **Exposed Machinery Casings** on the poop deck are to have the scantlings shown in **Table 42**, Col. A, without correction for draught. The doors are to be of steel, permanently attached and capable of being operated from both sides; the sills of the doorways are to be 15 inches above the deck.

6. **Pump Room Entrances.**—Houses protecting openings to pump rooms are to be strongly constructed. The doorways are to have 24 inch sills and are to be closed by hinged steel watertight doors.

Section 46.

OILTIGHT BULKHEADS.

1. **General.**—(*a*) Longitudinal bulkheads are to be oiltight throughout the cargo tanks but the plating may be perforated in cofferdams and also in pump rooms, provided suitable compensation is arranged.

Beyond the ends of the oil compartments the bulkheads are to scarph into the adjoining structure.

(*b*) For the arrangement of cofferdams, *see* **Section 40, clause 5.** The strength and stiffness of cofferdam bulkheads are to be as required for oiltight bulkheads.

(*c*) For the support of transverse bulkheads at the ends of tanks exceeding 35 feet in length, *see* **Table 64,** Note 2.

2. **Plating.**—Bulkheads may be plated horizontally or vertically and the thickness of plating is to be in accordance with **Table 71** and associated Notes.

3. **Stiffening and Support.**—(*a*) Bulkheads may be stiffened by horizontal or vertical stiffeners supported as necessary by vertical webs or horizontal girders.

(*b*) The scantlings of horizontal or vertical stiffeners are to be derived from **Table 72** and associated Notes.

(*c*) For transverse bulkheads the scantlings of vertical webs and horizontal girders are to be derived from **Table 64** and associated Notes.

(*d*) For longitudinal bulkheads the scantlings and arrangements of the vertical webs and horizontal girders are to be generally as required for the side of the ship. *See* **Section 41,** and **Tables 60, 63, & 64.**

4. (*a*) Stiffeners are to be bracketed or otherwise connected at their ends to provide adequate fixity, and, for horizontal stiffeners, continuity of strength at the bulkheads. The end brackets of longitudinal bulkhead vertical stiffeners are to be as required by **Table 76 (F).**

All stiffeners are to be connected to the supporting webs or girders. *See* **Table 76 (E).**

(*b*) The plating of transverse bulkheads is to be effectively stiffened to support loads transmitted by end connections of longitudinal bulkhead, shell and deck longitudinals.

(*c*) Vertical webs and horizontal girders are to be attached at their ends by flanged brackets of which the length of the arms is to be equal to the depth of the web.

5. **Corrugated Bulkheads.**—(*a*) The strength and stiffness of corrugated bulkheads are to be not less than required for flat bulkheads.

(*b*) Corrugations may be arranged vertically at transverse bulkheads only; they are to be of the same form at each side of horizontal girders. Vertical webs or horizontal girders are to be provided as necessary to support the bulkhead structure and to maintain the rigidity of the corrugations.

(*c*) Structural continuity is to be maintained at the junction of longitudinal and transverse bulkheads. All brackets or similar connections are to be arranged to minimise local stresses in the bulkhead plating either by easy tapering or by local plating reinforcement.

Section 47.

STRUCTURAL ARRANGEMENTS AT FORE END.

1. **General.**—The following requirements are applicable to Tankers framed transversely forward of the forward cofferdam and having deep tanks between the cofferdam and the fore peak. If other arrangements are adopted equivalent strength is to be provided.

2. **Frame Spacing.**—Frames between the forward cofferdam and the fore peak bulkhead are to be spaced 27 inches apart or as required by **Table 12,** whichever is less.

3. **Bottom Construction.**—(*a*) Bottom longitudinals in the forward ·2L in the centre cargo tanks are to be supported by additional intermediate transverses which may be of reduced depth but not less than the depth of the longitudinals. Alternatively, if the bottom longitudinals are riveted (*see* **Table 76 H**) intermediate transverses need not be fitted.

(*b*) In deep tanks floors are to be fitted at every frame. The scantlings of floors are to be determined from **Table 73** and associated Notes.

(*c*) Intercostal side girders are to be fitted between the floors, in line with alternate bottom longitudinals in the forward cargo tanks, and are to be extended as far forward as practicable.

(*d*) The thickness of the three strakes of shell plating next to the keel plate, or, in small ships, two strakes provided these cover the flat of bottom, between ·05L and ·25L from the fore end is to be determined from **Table 74** and associated Notes.

4. **Side Framing.**—(*a*) The scantlings of frames in deep tanks are to be determined from **Table 12** and associated Notes, the depth **h** being measured at the mid-length of the tank from the top of floors to the tank top at side. The frames are to be attached to the floors by efficient brackets.

In tanks of unusual depth **h** may be measured to a suitable side stringer (*see* **clause 5**) provided the strength of this stringer, and of the supporting webs, is adequately increased.

If the spacing differs from that required by **clause 2** above, the modulus is to be modified in direct proportion.

(*b*) In the hold above the deep tank the scantlings of frames are to be determined from **Table 12** and associated Notes, **h** being measured at the mid-length of the hold from the tank top to the lowest deck at side, but the resulting modulus may be multiplied by a factor equal to 1 minus half the ratio of the depth of the tank, at mid-length, to the depth D of the ship amidships.

$1 - \frac{\text{DEPTH OF TANK}}{2\,D.}$

(*c*) The scantlings of frames in 'tween decks of normal height are to be determined from **Table 13,** Col. D and associated Notes. If the 'tween deck height exceeds 10 feet the arrangements will be specially considered.

5. **Web Frames and Side Stringers.**—(*a*) Web frames of scantlings derived from **Table 75** and associated Notes are to be fitted not more than four frame spaces apart and are to extend from the floors to the first flat or deck above the load water line.

(*b*) Side stringers are to have scantlings required by **Table 75** and associated Notes. Those in the deep tank

are to be in line with the stringers in the fore peak, but above the deep tank top stringers may be fitted about 8 feet apart.

(*c*) Web frames are to be suitably bracketed at top and bottom and stringers are to be bracketed to the bulkheads.

The stringer web plates and face plates are to be efficiently connected to the web frames.

6. **Deep Tank Top.**—The scantlings and arrangements of the deep tank top are to be as required by **Section 19, clause 2.**

7. **Fore Peak.**—The scantlings and arrangements are to comply with **Section 9, clause 2.**

8. **Continuity of Strength** is to be maintained at the scarphing of the longitudinal and transverse framing and in cofferdams.

For structural details and connections *see* **Section 49** and **Table 76.**

Section 48.

STRUCTURAL ARRANGEMENTS AT AFTER END.

1. **General.**—The following requirements are applicable when a system of transverse framing, including that of the bottom and deck, is adopted; if longitudinal framing is used equivalent strength is to be provided.

2. **Double Bottom.**—The scantlings and arrangements of the double bottom are to be suitable to the type and power of the machinery, but are not to be less in strength or effectiveness than required by **Section 5** for the midship portion of the double bottom.

3. **Transverse Framing.**—(*a*) The scantlings of the side frames are to be determined from **Table 12** and associated Notes, **h** being measured at the fore end of the machinery space from the top of the double bottom at side to the lowest deck, flat or equivalent wide stringer.

(*b*) If the frames are supported at about mid-height by a stringer having the scantlings required by **clause 4** (*c*) below, the modulus of the frames may be reduced by 30 per cent.

4. **Web Frames and Side Stringers.**—(*a*) Web frames in the machinery space are to be fitted not more than five frame spaces apart, and are to have scantlings derived from **Table 75** and associated Notes, but **h** is to be measured as required by **clause 3** (*a*) above. The face area, unless a stringer is fitted, may be half the area required by the Table and Notes, but not less than the area of a $3\frac{1}{2}$ inch flange; if a stringer is fitted the face area of the web frame is to be the area required by the Table and Notes.

(*b*) Above the lowest deck, or equivalent, webs are to be fitted in line with those below and are to extend to the strength deck. The depth and thickness of these webs are to be determined using a value of 12 feet for **h**, without corrections, but need not exceed the depth and thickness of the lower webs. The face is to be stiffened by a $3\frac{1}{2}$ inch flange, or equivalent.

(*c*) If it is desired to fit a stringer, the depth and thickness of the stringer web plate are to be the same as required for the web frames, but the edge may be stiffened by a $3\frac{1}{2}$ inch flange, or equivalent.

(*d*) Web frames are to be suitably bracketed at top and bottom and stringers are to be bracketed to the bulkheads. The stringer web plates and face plates are to be efficiently connected to the web frames.

5. **Strong Beams and Pillars.**—Strong beams or other efficient cross-ties are to be fitted in the machinery openings at as low a level as practicable, and are to be connected to web frames. When this is impracticable, the size of the openings is to be restricted. Efficient pillaring is to be provided.

6. **Decks.**—Decks in the machinery space are to be constructed in accordance with **Sections 11, 14** and **15** and the appropriate Tables.

7. **Oil Fuel Bunkers.**—The structural arrangements in the cargo tanks are to be maintained in oil fuel bunkers at the fore end of machinery spaces. The scantlings of the sides, bottom and deck are to be as required for cargo tanks, but the scantlings of the bulkheads are to comply with the requirements of **Section 20.**

8. **After Peak.**—The scantlings and arrangements are to comply with **Section 9, clause 4.**

9. **Continuity of Strength** is to be maintained at the scarphing of the longitudinal and transverse framing and in cofferdams.

LONGL FRAMING AT SIDES & BOTTOM CAN BE ACCEPTED TERMINATING FORD OF THE POOP. J.M.M. 5/9/51.

The longitudinal deck framing is to extend to at least one-third of the breadth of the ship into the poop. The terminating positions of the longitudinal system at sides and bottom are to be staggered, and should not coincide with the position of the poop front bulkhead.

For structural details and connections, *see* **Section 49** and **Table 76.**

Section 49.

STRUCTURAL DETAILS.

1. **Transverses and Webs, Stringers and Girders.**—All primary supporting members, such as transverses and webs, stringers and girders, are to be so arranged that effective continuity of strength throughout their length is ensured and abrupt changes in depth or section at their connections are avoided; if the edges are flanged, the junction of the flange of the member itself with that of the bracket is to be of careful design and execution. Primary supporting members are to have adequate end fixity, web stiffening and lateral support. The following clauses are to be complied with or equivalent alternatives provided.

2. **Arrangements at ends of primary supporting members.**—(*a*) When face plates are carried continuously along the edges of end brackets of primary supporting members, their butts are to be kept clear of the toes of the brackets.

If not carried along the edge of the bracket the face plates of these members are to extend a reasonable distance beyond the toes of the brackets.

(*b*) End brackets are to be stiffened as follows:—

Length of Free Edge		Bracket Stiffening	
Above	Not exceeding	Flange or Face Plate	Additional Flat Stiffr.
Inches	Inches	Inches	Inches
	50	4	
50	65	5	
65	80	5	4
80	100	6	4
100		8	5

The bracket stiffener is to be parallel to the free edge and generally not more than a quarter of the throat depth from it.

(*c*) When a bracket is attached to a flat on bulkhead plating the flat is to be well tapered off beyond the toe of the bracket.

(*d*) Where members abut on both sides of bulkheads or on other members care is to be taken that they are in alignment.

(*e*) Where a bracket or the end of a member is attached to unsupported plating arrangements are to be made to distribute the load effectively.

3. **Web Stiffening.**—Stiffeners are to be fitted to web plates at each frame, longitudinal or bulkhead stiffener or as otherwise necessary.

Stiffeners are to have the following scantlings or equivalent:—

Depth of Girder		Stiffeners		
Above	Not exceeding			
Inches	Inches	Inches		
	20	3	Flats	All long
20	24	3	Flats	Short & long alt.
24	36	5	Flats	Short & long alt. All long in way of end bkts.
36	48	6	Flats	All long
48	60	7	Flats	All long
60	72	6 × 3	Toe Welded Angles	All long
72		7 × 3	Toe Welded Angles	All long

The depth of stiffeners is not to be less than required for the connection given in **Table 76 (E).**

Long stiffeners are to extend to the face edge of the web but need only be attached to the face if required by **clause 4.**

Short stiffeners are to extend to half the depth of the web, but at least beyond the lightening holes and 6 inches beyond the notches.

4. **Lateral Stability.**—Tripping brackets are to be fitted at suitable intervals. In general, they should be fitted near the toes of the end brackets and where the span is long additional brackets are to be fitted as necessary.

Alternatively, web stiffeners may be tapered so as to provide a wide base capable of giving lateral stability as well as stiffening the web.

Face plates of considerable width are to be supported if necessary against tripping.

OVER 7" B.A. OR 6" FLAT (EACH SIDE)

SCOTTS Nº 657. DK TRANSVERSE WITH 11" FLANGE STIFFNG. FLATS ATTACHED TO FLANGE. C.L. DK GIRDER, 12" FLANGE: T.B. AT ALT.

5. **Notches.**—All notches in web plates are to be well rounded and to have smooth edges. When notches occur at points where stress concentration may develop, such as near the toes of brackets, a welded collar or equivalent reinforcement is to be fitted.

6. **Lightening and Access Holes.**—The diameter of lightening holes is not to exceed 20 per cent of the depth of the web ; the holes should be placed at not less than half the depth of the web from the face and equidistant from the corners of notches for frames or stiffeners. Lightening holes are not to be cut in horizontal girders on the ship's side and longitudinal bulkheads. Access holes or foot holes may be cut in deep bottom transverses and centre girders with suitable compensation if necessary. All holes are to have smooth edges and are to be kept well clear of notches and the toes of brackets.

7. **Drain and Air Holes.**—Small drain or air holes may be cut in deep framing members and in longitudinals and stiffeners. These holes should be kept clear of the toes of end brackets and are to be well rounded with smooth edges.

8. **Minimum Thicknesses.**—No part of the structure within cargo tanks and cofferdams is to be less in thickness than required by **Table 77.**

9. **Welded Connections.**—For the requirements of welded connections and for details of scalloped construction *see* **Table 76.** Scallops are not to be cut in way of end brackets.

10. **Riveted Construction.**—In riveted construction arrangements are to be generally equivalent to the above requirements and the riveting is to be as required by **Table 76.**

Section 50.

HATCHWAYS.

1. **Oiltight Hatchways.**—(*a*) Oiltight hatchways are to be kept to the minimum size required to provide reasonable access and ventilation to each compartment. The corners of hatchways are to be well rounded and smooth.

(*b*) The coamings and covers are to be as required by **clauses 2** and **3** below.

(*c*) The arrangements at hatchways for ventilation and sounding are to be as required by the **Rules for Pumping and Piping.**

2. **Coamings.**—Coaming plates not exceeding 32 inches in height are to be ·40 inch in thickness.

3. **Covers.**—(*a*) Where the area of the hatchway cover does not exceed 12 square feet in a circular hatchway, or 16 square feet in a rectangular hatchway, the thickness of the cover is to be ·50 inch.

If the area exceeds the above but does not exceed 25 square feet the thickness of the cover is to be ·60 inch, or may be ·50 inch if stiffened by 4 inch flats spaced 24 inches apart.

(*b*) Covers are to be secured by fastenings spaced not more than 18 inches apart in a circular hatchway, or 15 inches apart in a rectangular hatchway and not more than 9 inches from the corners.

4. **Hatchways to Spaces other than Oil Compartments.**—Hatchways are to be constructed in accordance with the requirements of **Section 23** except that efficient steel watertight covers are to be fitted in the following positions :—

(1) Hatchways situated on the strength deck, either where exposed or inside open superstructures or superstructures closed as described in **Section 23, clause** 1 (*d*).

(2) Hatchways situated on the forecastle deck where the forecastle is either intact or closed by strong hinged steel doors.

(3) Hatchways situated on a forecastle deck and trunked between the forecastle deck and the strength deck.

Section 51.

TESTING.

1. **General.**—Each cargo tank and cofferdam is to be separately tested, either before the ship is launched or afterwards in dry dock, by filling with water to the test head.

2. **Test Head.**—The test head for cargo tanks and cofferdams is to be 8 feet above the highest point of the tank or cofferdam, excluding hatchways.

3. **Bunkers and Deep Tanks** are to be tested as required by **Section 19, clause 8,** and **Section 20, clause 14,** respectively.

For Special Surveys of Petroleum Tankers *see* **Periodical Survey Requirements, Section 3.**

NOTE.—Pumping arrangements and Ventilation of Cargo Tanks *see* **Rules for Pumping and Piping.**

71, FENCHURCH STREET, LONDON, E.C.3.
15th December, 1949.

TABLES OF SCANTLINGS

FOR

PETROLEUM TANKERS

LIST OF TABLES.

Table		Page
60	Bottom and Side Transverses, Vertical Webs on Longitudinal Bulkheads, Continuous Centre Line Bottom Girder	208
61	Deck Transverses	210
62	Intercostal Centre Line Bottom Girder	212
63	Side Transverses and Vertical Webs on Longitudinal Bulkheads, supported by two Cross-Ties	213
64	Side Stringers, Horizontal Girders on Longitudinal and Transverse Bulkheads, Vertical Webs on Transverse Bulkheads...	214
65	Centre Line Deck Girder	216
66	Cross-Ties in Wing Tanks	216
67	Bottom and Deck Longitudinals...	217
68	Side Longitudinals	218
69	Transverse Side Frames in Cargo Tanks	220
70	Shell and Strength Deck Plating	222
71	Bulkhead Plating	225
72	Bulkhead Stiffeners	226
73	Floors at Fore End	227
74	Bottom Plating Forward	227
75	Web Frames and Side Stringers at Fore End	228
76	Welding and Riveting	229
77	Minimum Thickness of Structure in Cargo Tanks and Cofferdams	239
	Sketch of Span Point	239

TABLE 60

BOTTOM AND SIDE TRANSVERSES.

VERTICAL WEBS ON LONGITUDINAL BULKHEADS.

CONTINUOUS CENTRE LINE BOTTOM GIRDER.

SPAN.	NUMERAL.															
	200	220	240	260	280	300	320	340	360	380	400	420	440	460	480	500
Feet.	DEPTH AND THICKNESS OF WEB IN INCHES. FACE AREA IN SQUARE INCHES.															
8	33×·38 1·4	33×·38 1·4	34×·38 1·5	34×·40 1·6	35×·40 1·7	35×·42 1·8	36×·42 1·9	36×·44 2·0	36×·44 2·1	37×·44 2·2	38×·46 2·4	40×·46 2·5				
10	34×·38 1·5	34×·38 1·7	35×·40 1·8	35×·40 1·9	36×·40 2·0	36×·42 2·4	37×·42 2·8	37×·44 3·0	37×·44 3·2	38×·44 3·3	40×·46 3·4	42×·46 3·4				
12	35×·38 2·5	36×·40 2·9	37×·40 3·2	37×·40 3·6	38×·42 3·9	38×·42 4·3	39×·42 4·6	39×·44 5·0	40×·44 5·3	41×·44 5·3	43×·46 5·3	45×·46 5·3	46×·46 5·3			
14	37×·40 4·1	38×·40 4·6	39×·40 5·0	40×·40 5·6	40×·42 6·0	41×·42 6·5	41×·42 6·9	42×·44 7·3	43×·44 7·7	45×·44 7·8	47×·46 7·8	48×·46 7·9	49×·46 7·9	50×·46 7·9		
16	39×·40 5·7	40×·40 6·4	41×·42 7·0	42×·42 7·5	43×·42 8·0	44×·42 8·6	45×·44 9·0	46×·44 9·5	47×·44 10·0	48×·46 10·2	50×·46 10·4	51×·46 10·6	53×·46 10·6	54×·48 10·6	56×·48 10·6	59×·48 10·6
18	42×·42 7·2	43×·42 8·0	44×·42 8·7	45×·42 9·5	46×·42 10·2	47×·44 10·8	48×·44 11·4	49×·44 12·0	50×·46 12·6	51×·46 12·8	53×·46 12·9	55×·46 12·9	57×·48 13·0	59×·48 13·0	60×·48 13·0	62×·48 13·0
20		45×·42 9·0	46×·42 9·4	47×·44 10·1	48×·44 10·9	50×·44 11·5	51×·44 12·0	52×·46 12·6	53×·46 13·1	54×·46 13·5	56×·48 13·8	58×·48 14·0	59×·48 14·2	61×·48 14·2	63×·48 14·3	64×·48 14·3
22			49×·44 10·0	50×·44 10·6	51×·44 11·3	53×·46 11·8	54×·46 12·3	55×·46 13·0	56×·46 13·6	57×·48 14·1	59×·48 14·6	61×·48 14·9	62×·48 15·2	64×·48 15·4	65×·50 15·5	66×·50 15·5
24				53×·46 10·8	54×·46 11·4	55×·46 12·0	57×·48 12·6	58×·48 13·4	59×·48 14·0	60×·48 14·8	61×·48 15·4	63×·50 15·8	64×·50 16·2	66×·50 16·5	67×·50 16·7	68×·50 16·8
26				56×·48 10·8	57×·48 11·4	58×·48 12·0	60×·48 12·9	61×·50 13·8	62×·50 14·5	63×·50 15·4	64×·50 16·1	65×·50 16·7	66×·50 17·3	67×·50 17·6	69×·50 17·9	70×·50 18·1
28					60×·50 11·5	61×·50 12·1	62×·50 13·2	63×·50 14·1	64×·50 15·0	65×·50 16·0	66×·50 16·8	67×·50 17·6	68×·50 18·3	69×·50 18·8	70×·50 19·2	72×·50 19·3
30						63×·50 12·2	64×·50 13·6	65×·50 14·7	66×·50 15·7	67×·50 16·7	68×·50 17·6	69×·50 18·5	70×·50 19·3	71×·50 19·9	72×·50 20·5	74×·50 20·5
32							66×·50 13·9	67×·50 15·2	68×·50 16·4	69×·50 17·4	70×·50 18·3	71×·50 19·4	72×·50 20·5	73×·50 21·0	74×·50 21·5	76×·50 21·7
34								69×·50 15·8	70×·50 17·1	71×·50 18·1	72×·50 19·0	73×·50 20·3	74×·50 21·4	75×·50 22·0	76×·50 22·5	78×·50 22·8
36									72×·50 17·7	73×·50 18·7	74×·50 19·7	75×·50 21·2	76×·50 22·3	77×·50 23·0	78×·50 23·6	80×·50 23·8

NOTES.—TABLE 60.

1. **Numeral** is to be calculated as follows :—

(*a*) For Bottom Transverses

Numeral = s × D

Where s = spacing of transverses, in feet

D = Moulded Depth of ship, in feet.

(*b*) For Centre Line Bottom Girders supporting Transverses

Numeral = b × D

Where b = half breadth of centre tank, in feet.

D = Moulded Depth of ship, in feet.

(*c*) For Side Transverses and Longitudinal Bulkhead Vertical Webs supporting longitudinals or horizontal girders

Numeral = 1·4 s × h

Where s = spacing of transverses, in feet

h = vertical distance in feet from the mid point of the span to the deck at side, amidships.

Side Transverses or webs which are supported by crossties are to be in accordance with **Table 63.**

TABLE 60

BOTTOM AND SIDE TRANSVERSES.

VERTICAL WEBS ON LONGITUDINAL BULKHEADS.

CONTINUOUS CENTRE LINE BOTTOM GIRDER.

NUMERAL.															SPAN.
520	540	560	580	600	620	640	660	680	700	720	740	760	780	800	
DEPTH AND THICKNESS OF WEB IN INCHES. FACE AREA IN SQUARE INCHES.															Feet
															8
															10
															12
															14
															16
64×·48 13·0															18
66×·50 14·3	68×·50 14·3	70×·50 14·3	72×·50 14·3	74×·50 14·3	76×·50 14·3	77×·50 14·3	79×·50 14·3	80×·50 14·3	81×·50 14·3	82×·52 14·3					20
68×·50 15·6	70×·50 15·6	72×·50 15·6	74×·50 15·6	76×·50 15·6	78×·50 15·6	79×·50 15·6	81×·50 15·6	82×·50 15·6	84×·52 15·6	85×·52 15·6	87×·52 15·6	89×·52 15·6			22
70×·50 16·9	72×·50 16·9	74×·50 16·9	76×·50 16·9	78×·50 16·9	79×·50 16·9	81×·50 16·9	83×·50 16·9	84×·52 16·9	86×·52 16·9	88×·52 16·9	90×·52 16·9	92×·52 16·9	94×·52 16·9	96×·52 16·9	24
72×·50 18·1	74×·50 18·1	76×·50 18·1	78×·50 18·1	80×·50 18·1	82×·50 18·1	84×·50 18·1	86×·52 18·1	87×·52 18·1	89×·52 18·1	91×·52 18·1	93×·52 18·1	94×·52 18·1	96×·52 18·1	98×·52 18·1	26
74×·50 19·4	76×·50 19·4	78×·50 19·4	80×·50 19·4	82×·50 19·4	84×·50 19·4	86×·52 19·4	88×·52 19·4	90×·52 19·4	92×·52 19·4	94×·52 19·4	95×·52 19·4	97×·52 19·4	99×·52 19·4	100×·52 19·4	28
76×·50 20·6	78×·50 20·6	80×·50 20·7	82×·50 20·7	84×·50 20·7	86×·52 20·7	88×·52 20·7	90×·52 20·7	92×·52 20·7	94×·52 20·7	96×·52 20·7	97×·52 20·7	99×·52 20·7	101×·52 20·7	103×·52 20·7	30
78×·50 21·7	80×·50 21·8	82×·50 21·9	84×·50 21·9	86×·52 21·9	88×·52 21·9	90×·52 21·9	92×·52 21·9	94×·52 21·9	96×·52 21·9	98×·52 21·9	100×·52 21·9	102×·52 21·9	104×·52 21·9	106×·52 21·9	32
80×·50 23·0	82×·50 23·1	84×·50 23·1	86×·52 23·1	88×·52 23·1	90×·52 23·1	92×·52 23·1	94×·52 23·1	96×·52 23·1	98×·52 23·1	100×·52 23·1	102×·52 23·1	104×·52 23·1	106×·52 23·1	109×·52 23·1	34
82×·50 24·0	84×·50 24·2	86×·52 24·3	88×·52 24·3	90×·52 24·3	92×·52 24·3	94×·52 24·3	96×·52 24·3	98×·52 24·3	100×·52 24·3	102×·52 24·3	104×·52 24·3	106×·52 24·3	109×·52 24·3	112×·52 24·3	36

NOTES.—TABLE 60 (*continued*).

2. **Span** is the distance in feet from "Span Point" to "Span Point" (*see* Sketch, page 239).

3. **Depth** given in the Table is the depth of the web plate.

4. Vertical Webs on Longitudinal Bulkheads may have web plates 10 per cent less in thickness than required by the Table.

5. **Minimum Requirements.**

(*a*) For Bottom Transverses the depth of web is not to be less than ·055 B, where B is the moulded breadth in feet, modified at the rate of 5 per cent per foot of difference between the spacing of the transverses and 10 feet.

(*b*) No part of the structure within cargo tanks and cofferdams is to be less in thickness than required by **Table 77.**

6. This Table does not apply to corrugated bulkheads.

TABLE 61

DECK TRANSVERSES.

SPAN.	NUMERAL.							
	40	44	48	52	56	60	64	68
Feet.	DEPTH AND THICKNESS OF WEB IN INCHES. FACE AREA IN SQUARE INCHES.							
8	24 × ·40 2·5	25 × ·40 2·6	26 × ·40 2·7	27 × ·41 2·8	27 × ·41 2·9	28 × ·41 3·0	29 × ·42 3·1	30 × ·42 3·2
9	25 × ·40 2·6	26 × ·40 2·7	27 × ·40 2·8	28 × ·41 2·9	28 × ·41 3·0	29 × ·41 3·1	30 × ·42 3·2	31 × ·42 3·3
10	25 × ·40 2·8	26 × ·40 2·9	27 × ·40 3·0	28 × ·41 3·1	29 × ·41 3·2	29 × ·41 3·3	30 × ·42 3·4	31 × ·42 3·5
11	26 × ·40 2·9	27 × ·40 3·0	28 × ·40 3·1	28 × ·41 3·2	29 × ·41 3·3	30 × ·41 3·4	30 × ·42 3·5	31 × ·42 3·6
12	26 × ·40 3·0	27 × ·40 3·1	28 × ·40 3·3	29 × ·41 3·4	30 × ·41 3·5	31 × ·41 3·6	31 × ·42 3·7	32 × ·42 3·8
13	27 × ·40 3·2	28 × ·40 3·3	29 × ·40 3·4	30 × ·41 3·5	31 × ·41 3·7	31 × ·41 3·8	32 × ·42 3·9	33 × ·42 4·0
14	27 × ·40 3·4	28 × ·40 3·5	29 × ·40 3·6	30 × ·41 3·7	31 × ·41 3·9	32 × ·41 4·0	33 × ·42 4·1	34 × ·42 4·2
15	27 × ·40 3·6	28 × ·40 3·7	29 × ·40 3·9	30 × ·41 4·0	31 × ·41 4·1	32 × ·41 4·2	33 × ·42 4·3	34 × ·42 4·4
16	28 × ·40 3·9	29 × ·40 4·0	30 × ·40 4·1	31 × ·41 4·2	32 × ·41 4·3	33 × ·41 4·4	34 × ·42 4·5	35 × ·42 4·6

NOTES.—TABLE 61.

1. **Numeral** is to be calculated as follows :—

For Centre Tank

(*a*) Numeral = ·015 s × L

For Wing Tanks

(*b*) Numeral = ·011 s × L

Where s = Spacing of Transverse, in feet

L = Length of ship, in feet.

2. **Span** is the distance in feet from "Span Point" to "Span Point" of the transverse (*see* Sketch, page 239).

TABLE 61

DECK TRANSVERSES.

NUMERAL.								SPAN.
72	76	80	84	88	92	96	100	
DEPTH AND THICKNESS OF WEB IN INCHES. FACE AREA IN SQUARE INCHES.								Feet.
30 × ·42 3·3	31 × ·43 3·4	31 × ·43 3·5	32 × ·43 3·7	33 × ·44 3·8	34 × ·44 3·9	34 × ·44 4·0	35 × ·44 4·1	8
31 × ·42 3·5	32 × ·43 3·6	32 × ·43 3·7	33 × ·43 3·9	34 × ·44 3·9	35 × ·44 4·1	35 × ·44 4·2	36 × ·44 4·3	9
32 × ·42 3·6	32 × ·43 3·7	33 × ·43 3·9	33 × ·43 4·0	34 × ·44 4·1	35 × ·44 4·3	36 × ·44 4·4	36 × ·44 4·5	10
32 × ·42 3·8	33 × ·43 3·9	33 × ·43 4·1	34 × ·43 4·2	35 × ·44 4·3	36 × ·44 4·5	37 × ·44 4·6	37 × ·44 4·8	11
33 × ·42 4·0	34 × ·43 4·1	34 × ·43 4·3	35 × ·43 4·4	36 × ·44 4·6	37 × ·44 4·7	37 × ·44 4·8	38 × ·44 5·0	12
34 × ·42 4·1	35 × ·43 4·3	35 × ·43 4·5	36 × ·43 4·6	36 × ·44 4·8	37 × ·44 4·9	38 × ·44 5·1	39 × ·44 5·2	13
35 × ·42 4·3	36 × ·43 4·5	36 × ·43 4·7	37 × ·43 4·8	38 × ·44 5·0	38 × ·44 5·1	39 × ·44 5·3	39 × ·44 5·5	14
35 × ·42 4·5	36 × ·43 4·7	37 × ·43 4·9	38 × ·43 5·0	39 × ·44 5·2	39 × ·44 5·3	40 × ·44 5·5	40 × ·44 5·7	15
36 × ·42 4·8	37 × ·43 4·9	38 × ·43 5·1	39 × ·43 5·3	40 × ·44 5·4	40 × ·44 5·6	41 × ·44 5·7	41 × ·44 5·9	16

NOTES.—TABLE 61 (*continued*).

3. **Depth** given in the Table is the depth of the web plate.

4. **Minimum Requirements.**—(*a*) The depth of web is not to be less than ·04 B, where B is the moulded breadth in feet, modified at the rate of 5 per cent per foot of difference between the spacing of the transverses and 10 feet.

(*b*) No part of the structure within cargo tanks and cofferdams is to be less in thickness than required by **Table 77.**

TABLE 62

INTERCOSTAL CENTRE LINE BOTTOM GIRDER.

B × D	GIRDER DEPTH AND THICKNESS.	FACE AREA.
	Inches.	Square Inches.
1000	35 × ·38	3·5
1500	41 × ·40	3·8
2000	47 × ·42	4·1
2500	53 × ·44	4·4
3000	60 × ·46	4·7
3500	68 × ·48	5·0

NOTES.—TABLE 62.

1. B and D are the moulded breadth and depth of the ship, in feet.

2. **Correction for Spacing of Transverses.**

The depth of the girder is to be modified at the rate of 5 per cent per foot of difference between the spacing of transverses and 10 feet. The face area is to remain unaltered.

3. Depth of girder need not exceed depth of the bottom transverses, but if this is less than the depth derived from the Table the face area is to be suitably increased.

4. **Minimum Thicknesses.**—No part of the structure within cargo tanks and cofferdams is to be less in thickness than required by **Table 77.**

TABLE 63

SIDE TRANSVERSES AND VERTICAL WEBS ON LONGITUDINAL BULKHEADS, SUPPORTED BY TWO CROSS-TIES.

DEPTH D	DEPTH OF WEB.		THICKNESS OF SIDE TRANSVERSE WEB PLATE.	FACE AREA.
	TRANSVERSE FRAMING.	LONGITUDINAL FRAMING.		
Feet.	Inches.	Inches	Inches.	Square Inches
26		20	·38	2·0
28		22	·40	2·2
30	20	24	·40	2·4
32	22	26	·42	2·6
34	24	28	·42	2·8
36	28	32	·44	2·8
38	32	36	·44	3·0
40	36	40	·46	3·0
42	40	44	·46	3·0
44	44	48	·48	3·0
46	48	52	·48	3·0

NOTES.—TABLE 63.

1. **Depth of web** given in the Table is the depth of the web plate.

2. **Correction for Spacing of Transverses.**—If the spacing of transverses differs from 10 feet the depth of web is to be modified at the rate of 5 per cent for every foot of difference. The face area and the thickness of web are to correspond with the corrected depth.

3. **Correction for number of cross-ties.**—When one cross-tie is fitted the depth of the web after correction by Note 2 if necessary, is to be increased by 15 per cent; when there are three cross-ties the depth may be reduced by 10 per cent.

4. **Webs on Longitudinal Bulkheads.**—Webs on longitudinal bulkheads may be 10 per cent less in thickness than required for side transverses.

5. The scantlings of side transverses and vertical webs on longitudinal bulkheads supporting longitudinals or horizontal girders, and not themselves supported by cross-ties, are not to be less than required by **Table 60** and associated Notes.

6. **Minimum Thicknesses.**—No part of the side transverses or vertical webs is to be less in thickness than required by **Table 77.**

7. This Table does not apply to corrugated bulkheads.

TABLE 64

SIDE STRINGERS.
HORIZONTAL GIRDERS ON LONGITUDINAL AND TRANSVERSE BULKHEADS.
VERTICAL WEBS ON TRANSVERSE BULKHEADS.

SPAN.	NUMERAL.								
	100	120	140	160	180	200	220	240	260
Feet.	DEPTH AND THICKNESS OF WEB IN INCHES. FACE AREA IN SQUARE INCHES.								
8	23 × ·38 1·2	23 × ·38 1·2	23 × ·38 1·3	24 × ·40 1·4	24 × ·40 1·4	24 × ·40 1·5	25 × ·40 1·5	26 × ·40 1·6	27 × ·42 1·7
9	24 × ·38 1·4	24 × ·38 1·5	24 × ·40 1·6	25 × ·40 1·7	25 × ·40 1·9	25 × ·40 2·1	26 × ·40 2·2	27 × ·40 2·3	28 × ·42 2·4
10	26 × ·38 1·6	26 × ·40 1·6	26 × ·40 1·8	27 × ·40 2·0	27 × ·40 2·2	27 × ·40 2·5	28 × ·40 2·7	29 × ·42 2·9	30 × ·42 3·1
11	27 × ·40 1·7	27 × ·40 1·7	27 × ·40 1·9	28 × ·40 2·1	28 × ·40 2·4	28 × ·42 2·8	29 × ·42 3·1	30 × ·42 3·4	31 × ·42 3·7
12	29 × ·40 1·9	29 × ·40 1·9	29 × ·40 2·0	30 × ·42 2·3	30 × ·42 2·7	30 × ·42 3·1	31 × ·42 3·5	32 × ·42 3·9	33 × ·42 4·3
14	32 × ·42 2·0	32 × ·42 2·0	33 × ·42 2·2	33 × ·42 2·7	34 × ·42 3·2	34 × ·42 3·8	35 × ·42 4·3	36 × ·44 4·8	37 × ·44 5·3
16	36 × ·42 2·0	36 × ·42 2·0	37 × ·42 2·4	37 × ·42 3·0	38 × ·42 3·7	38 × ·42 4·5	39 × ·44 5·3	40 × ·44 5·9	41 × ·44 6·4
18	40 × ·44 2·1	40 × ·44 2·1	41 × ·44 2·6	41 × ·44 3·4	42 × ·44 4·2	42 × ·44 5·0	43 × ·44 5·9	44 × ·44 6·7	45 × ·44 7·5
20	45 × ·44 2·2	45 × ·44 2·2	46 × ·44 2·8	46 × ·44 3·8	47 × ·44 4·8	47 × ·44 5·7	48 × ·44 6·6	49 × ·44 7·5	50 × ·46 8·4
22	49 × ·46 2·4	49 × ·46 2·4	50 × ·46 3·0	50 × ·46 4·2	51 × ·46 5·4	51 × ·46 6·4	52 × ·46 7·4	53 × ·46 8·4	54 × ·46 9·4
24	54 × ·48 2·6	54 × ·48 2·7	55 × ·48 3·2	55 × ·48 4·6	56 × ·48 6·0	56 × ·48 7·2	57 × ·48 8·4	58 × ·48 9·5	59 × ·48 10·6
26		57 × ·50 2·9	57 × ·50 3·4	58 × ·50 5·1	59 × ·50 6·7	59 × ·50 8·1	60 × ·50 9·5	61 × ·50 10·8	62 × ·50 12·1
28		61 × ·50 3·1	61 × ·50 3·6	61 × ·50 5·7	62 × ·50 7·7	62 × ·50 9·3	63 × ·50 10·8	64 × ·50 12·2	65 × ·50 13·7
30		63 × ·50 3·2	63 × ·50 3·8	64 × ·50 6·5	64 × ·50 9·2	65 × ·50 11·1	65 × ·50 12·6	66 × ·50 14·1	67 × ·50 15·7
32		66 × ·50 3·3	66 × ·50 3·9	67 × ·50 7·4	67 × ·50 10·6	68 × ·50 12·8	68 × ·50 14·4	69 × ·50 16·0	70 × ·50 17·7

SEE NOTE 3

NOTES.—TABLE 64.

1. **Numeral** is to be calculated as follows :—

(*a*) FOR LOWER STRINGERS AND HORIZONTAL GIRDERS AND FOR VERTICAL WEBS

Numeral = b × h

Where b = width in feet of plating supported.

For lower side stringers or girders b is to be taken as half the distance between the next stringer or girder and the base line. SOME ALLOWANCE MAY BE MADE WHERE LARGE BRACKETS ARE FITTED TO BOTTOM LONGLS. J.M.M. 5/9/51.

h = Vertical distance in feet from the mid-point of the span to the highest point of the tank, excluding the hatchway.

(*b*) FOR MIDDLE OR SINGLE STRINGERS AND GIRDERS

Numeral = b × h

(*c*) FOR UPPER STRINGERS AND GIRDERS

Numeral = 1·2 b × h

BUT UPPER GIRDER NOT GREATER THAN SECOND. J.M.M. 5/9/51.

TAKEN TO TOP OF BHD IN QUESTION L.O. PRACTICE. J.M.M. 5/9/51

TABLE 64

SIDE STRINGERS.
HORIZONTAL GIRDERS ON LONGITUDINAL AND TRANSVERSE BULKHEADS.
VERTICAL WEBS ON TRANSVERSE BULKHEADS.

NUMERAL.									SPAN.
280	300	320	340	360	380	400	420	440	
DEPTH AND THICKNESS OF WEB IN INCHES. FACE AREA IN SQUARE INCHES.									Feet.
27×·42 1·7	28×·42 1·8	29×·42 1·8	29×·42 1·9	30×·42 1·9	31×·44 2·0	32×·44 2·0	32×·44 2·1	33×·44 2·2	8
28×·42 2·6	29×·42 2·6	30×·42 2·7	30×·44 2·8	31×·44 2·8	32×·44 2·9	33×·44 2·9	34×·44 2·9	35×·44 2·9	9
30×·42 3·3	31×·42 3·4	32×·44 3·5	32×·44 3·6	33×·44 3·7	34×·44 3·8	35×·44 3·8	36×·44 3·9	37×·44 3·9	10
31×·42 4·0	32×·44 4·2	33×·44 4·3	34×·44 4·4	35×·44 4·5	36×·44 4·6	37×·44 4·7	38×·44 4·8	39×·44 4·8	11
33×·44 4·7	34×·44 5·0	35×·44 5·2	36×·44 5·3	37×·44 5·4	38×·44 5·5	39×·44 5·6	40×·46 5·7	41×·46 5·7	12
37×·44 5·8	38×·44 6·3	39×·44 6·6	40×·44 6·8	41×·46 7·0	42×·46 7·2	43×·46 7·4	44×·46 7·6	45×·46 7·7	14
41×·44 7·1	42×·44 7·7	43×·46 8·1	44×·46 8·4	45×·46 8·7	46×·46 9·0	47×·46 9·4	48×·46 9·7	49×·46 9·9	16
45×·46 8·2	46×·46 8·9	47×·46 9·5	48×·46 10·0	49×·46 10·5	50×·46 11·0	51×·48 11·4	52×·48 11·7	53×·48 11·9	18
50×·46 9·3	51×·46 10·1	52×·46 10·8	53×·48 11·5	54×·48 12·2	55×·48 12·8	56×·48 13·4	57×·48 13·9	58×·48 14·3	20
54×·46 10·4	55×·48 11·3	56×·48 12·1	57×·48 12·9	58×·48 13·7	59×·48 14·5	60×·48 15·3	61×·50 16·0	62×·50 16·6	22
59×·48 11·6	60×·48 12·5	60×·48 13·5	61×·50 14·5	62×·50 15·4	63×·50 16·3	64×·50 17·2	65×·50 18·0	66×·50 18·7	24
62×·50 13·4	63×·50 14·5	63×·50 15·7	64×·50 16·4	65×·50 18·0	66×·50 19·0	67×·50 19·7	68×·50 20·5	69×·50 21·5	26
65×·50 15·2	66×·50 16·5	67×·50 17·7	68×·50 19·0	69×·50 20·0	70×·50 21·5	71×·50 22·5	72×·50 23·0	73×·50 24·0	28
68×·50 17·3	69×·50 18·7	70×·50 20·0	71×·50 21·0	72×·50 23·0	73×·50 24·0	74×·50 25·0	75×·50 26·0	76×·50 27·0	30
71×·50 19·4	72×·50 21·0	73×·50 22·5	74×·50 23·5	75×·50 25·5	76×·50 26·5	77×·50 27·5	78×·50 29·0	79×·50 30·0	32

SEE NOTE 3.

NOTES.—TABLE 64 (*continued*).

2. **Long Tanks.**—If the length of tank exceeds 35 feet the Numeral for use on transverse bulkheads is to be increased in direct proportion.

3. **Span** is the distance in feet from "Span Point" to "Span Point" (*see* Sketch, page 239). For side stringers and horizontal girders on longitudinal bulkheads the span is not to be taken as less than 10 feet. MIN^M OF 10 FT SHOULD BE TAKEN WITHIN THE MIDSHIP ½ L: FORD OF THIS, THE MIN^M SPAN NEED NOT BE ADHERED TO, PROVIDED GIRDERS ARE NOT LESS THAN THOSE AMIDSHIPS. J.M.M. 5/9/51.

4. **Depth** given in the Table is the depth of the web plate.

5. **Side Stringers** are to have web plates 5 per cent thicker than required by the Table.

6. **Minimum Thicknesses.**—No part of the structure within cargo tanks and cofferdams is to be less in thickness than required by **Table 77.**

7. This Table does not apply to corrugated bulkheads.

TABLE 65

CENTRE LINE DECK GIRDER.

Length of Tank 35 feet.

NUMERAL.		40	50	60	70	80	90	100	110	120	130	140	150	160	170
GIRDER.	DEPTH. Inches.	53	53	54	54	55	56	58	60	62	64	66	69	72	75
	FACE AREA. Square Inches.	1·4	1·8	2·2	2·6	3·2	3·8	4·5	5·0	5·0	5·5	5·5	6·0	6·0	6·5

NOTES.—TABLE 65.

1. **Numeral** is to be calculated as follows :—

   Numeral = ·015 b × L (*See* **Section 2, clause 1**)

   Where b = Half-breadth of centre tank, in feet.

   L = Length of ship, in feet.

2. **Depth** given in the Table is the depth of web plate.

3. **Thickness** of the web plate is to be the same as the thickness of the deck transverses.

4. **Correction for Length of Tank.**—If the length of tank differs from 35 feet the depth of web is to be modified at the rate of 2 inches for every 5 feet of difference. The face area is to correspond with the corrected depth.

5. **Minimum Thicknesses.**—No part of the structure within cargo tanks and cofferdams is to be less in thickness than required by **Table 77.**

TABLE 66

CROSS-TIES IN WING TANKS.

NUMERAL.	SECTIONAL AREA OF CROSS-TIE.
	Square Inches.
5	12
10	15
15	18
20	20
25	22
30	24

NOTES.—TABLE 66.

1. **Numeral** is to be calculated as follows :—

$$\text{Numeral} = \frac{l \times s \times h}{100}$$

Where l = Vertical spacing of cross-ties in feet.

For the lower cross-tie l is to be taken as half the distance between the next cross-tie and the base line.

For the uppermost cross-tie l is to be taken as half the distance from the next cross-tie to the deck at side.

s = Spacing of transverses, in feet.

h = Vertical distance in feet from the cross-tie to the deck at side, amidships.

2. **Minimum Thicknesses.**—No part of the cross-tie is to be less in thickness than required by **Table 77.**

TABLE 67

BOTTOM & DECK LONGITUDINALS.

Spaced 30 inches apart and having a span of 10 feet.

LENGTH L	MODULUS OF LONGITUDINALS.	
	BOTTOM.	DECK.
Feet.	Inches^3.	Inches^3.
240	37·3	10·8
250	38·7	10·9
260	40·1	11·0
270	41·5	11·1
280	42·8	11·2
290	44·2	11·3
300	45·6	11·4
310	46·9	11·7
320	48·2	11·9
330	49·5	12·2
340	50·9	12·4
350	52·2	12·7
360	53·5	13·0
370	54·8	13·3
380	56·1	13·6
390	57·5	14·0
400	58·8	14·3
410	60·2	14·7
420	61·7	15·1
430	63·2	15·5
440	64·7	15·9
450	66·2	16·3
460	67·7	16·9
470	69·1	17·4
480	70·6	17·9
490	72·1	18·5
500	73·6	19·0
510	75·0	19·8
520	76·5	20·6
530	78·0	21·3
540	79·4	22·1
550	80·9	22·9
560	82·3	24·0
570	83·8	25·2
580	85·3	26·3
590	86·7	27·4
600	88·2	28·6
610	89·6	29·5
620	91·1	30·4

NOTES.—TABLE 67.

1. **Span** is to be measured from transverse to transverse or from transverse to the " span point " (*see* Sketch, page 239) of the end connection.

2. **Corrections to modulus of longitudinals.**

FOR SPAN :

If the span is $\begin{matrix}\text{greater}\\\text{less}\end{matrix}$ than 10 feet, modulus of longitudinals to be $\begin{matrix}\text{increased}\\\text{reduced}\end{matrix}$ at the rate of $\begin{matrix}20 \text{ per cent}\\15 \text{ per cent}\end{matrix}$ per foot of difference ; the modulus is not to be less than that required for an 8 feet spacing of transverses.

FOR SPACING OF LONGITUDINALS :

If the spacing of longitudinals differs from 30 inches, the modulus is to be modified in direct proportion.

3. For minimum thickness of longitudinals *see* **Table 77.**

4. Particulars of sections and moduli are given in **Table 56.**

LONG^{LS} IN WAY OF CORRUGATIONS ON TRASV. BHDS MAY REQUIRE TO BE INCREASED.

TABLE 68

SID

Spaced 30 inches apa

DEPTH D	HEAD—FEET																			
	Not exceeding 6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	2
Feet	<— Modulus—Inches³ —>																			
16	10·4	10·9	11·5	12·5	13·6	14·7	15·9	17·1	18·3											
17	10·6	11·0	11·5	12·6	13·6	14·8	16·0	17·1	18·3	19·4										
18	10·8	11·1	11·5	12·6	13·7	14·9	16·1	17·2	18·4	19·5	20·5									
19	11·0	11·2	11·5	12·6	13·7	15·0	16·2	17·3	18·5	19·6	20·7	21·7								
20	11·2	11·3	11·5	12·7	13·8	15·1	16·4	17·5	18·7	19·8	21·0	22·1	23·2							
21	11·3	11·4	11·5	12·7	13·8	15·2	16·5	17·6	18·8	20·0	21·2	22·3	23·5	24·6						
22	11·4	11·4	11·5	12·7	13·9	15·3	16·6	17·8	19·0	20·2	21·4	22·4	23·7	24·8	26·0					
23	11·5	11·5	11·5	12·7	13·9	15·4	16·7	18·0	19·2	20·4	21·6	22·7	23·9	25·0	26·2	27·3				
24	11·6	11·6	11·6	12·8	14·0	15·5	16·8	18·1	19·4	20·6	21·8	23·0	24·2	25·3	26·5	27·6	28·6			
25	11·7	11·7	11·7	12·9	14·2	15·6	17·0	18·3	19·6	20·8	22·1	23·3	24·5	25·6	26·8	27·8	28·8	29·8		
26	11·9	11·9	11·9	13·2	14·5	15·8	17·2	18·6	19·9	21·1	22·4	23·6	24·8	25·9	27·1	28·1	29·0	30·0	30·9	
27	12·0	12·0	12·0	13·4	14·7	16·1	17·5	18·8	20·2	21·4	22·7	23·9	25·1	26·2	27·4	28·3	29·3	30·2	31·1	32·0
28	12·2	12·2	12·2	13·6	15·0	16·4	17·8	19·1	20·5	21·7	23·0	24·2	25·4	26·5	27·7	28·6	29·6	30·5	31·4	32·3
29	12·4	12·4	12·4	13·9	15·3	16·6	18·0	19·4	20·7	22·0	23·2	24·5	25·7	26·8	28·0	29·0	29·9	30·9	31·8	32·7
30	12·6	12·6	12·6	14·0	15·5	16·9	18·3	19·7	21·0	22·3	23·5	24·7	26·0	27·2	28·3	29·3	30·2	31·2	32·1	33·
31	12·9	12·9	12·9	14·3	15·7	17·2	18·5	19·9	21·2	22·5	23·8	25·0	26·2	27·4	28·6	29·6	30·6	31·6	32·5	33·
32	13·2	13·2	13·2	14·6	16·0	17·5	18·8	20·2	21·5	22·8	24·1	25·3	26·5	27·7	28·9	30·0	31·0	32·0	32·9	33·
33	13·6	13·6	13·6	14·9	16·3	17·7	19·1	20·5	21·8	23·1	24·4	25·6	26·8	28·0	29·2	30·3	31·3	32·3	33·3	34·
34	14·0	14·0	14·0	15·2	16·6	18·0	19·4	20·8	22·1	23·4	24·7	26·0	27·2	28·4	29·5	30·6	31·6	32·6	33·6	34·
35	14·4	14·4	14·4	15·5	16·9	18·3	19·7	21·1	22·4	23·7	25·0	26·3	27·5	28·7	29·8	30·9	31·9	32·9	33·9	34·
36	14·9	14·9	14·9	15·9	17·2	18·5	20·0	21·4	22·7	24·1	25·4	26·7	27·9	29·1	30·2	31·2	32·3	33·3	34·3	35·
37	15·3	15·3	15·3	16·3	17·5	18·8	20·3	21·7	23·0	24·4	25·7	27·0	28·2	29·4	30·5	31·6	32·6	33·7	34·7	35·
38	15·8	15·8	15·8	16·7	17·8	19·1	20·6	22·0	23·3	24·7	26·0	27·3	28·6	29·8	30·9	32·0	33·0	34·1	35·1	36·
39	16·2	16·2	16·2	17·1	18·1	19·4	20·9	22·3	23·6	25·0	26·3	27·7	29·0	30·2	31·3	32·4	33·4	34·5	35·5	36·
40	16·7	16·7	16·7	17·5	18·4	19·7	21·2	22·6	24·0	25·4	26·7	28·1	29·4	30·6	31·7	32·8	33·9	34·9	35·9	36·
41	17·2	17·2	17·2	17·9	18·8	20·0	21·5	23·0	24·4	25·8	27·1	28·5	29·8	31·0	32·1	33·2	34·3	35·4	36·4	37·
42	17·7	17·7	17·7	18·3	19·2	20·4	21·9	23·4	24·9	26·3	27·6	28·9	30·2	31·4	32·5	33·7	34·8	35·9	36·9	37·
43	18·2	18·2	18·2	18·7	19·5	20·7	22·3	23·8	25·3	26·7	28·0	29·4	30·7	31·9	33·0	34·2	35·3	36·4	37·4	38·
44	18·7	18·7	18·7	19·1	19·8	21·1	22·7	24·2	25·7	27·1	28·5	29·9	31·2	32·4	33·6	34·7	35·8	36·9	37·9	38·
45	19·2	19·2	19·2	19·5	20·1	21·5	23·1	24·6	26·1	27·6	29·0	30·4	31·7	33·0	34·2	35·3	36·3	37·4	38·4	39·
46	19·7	19·7	19·7	19·9	20·5	21·9	23·5	25·0	26·5	28·0	29·5	30·9	32·2	33·5	34·8	35·8	36·8	37·8	38·8	39·

NOTES.—TABLE 68.

1. **Span** is to be measured from transverse to transverse or from transverse to "span point" (*see* Sketch, page 239) of the end connection.
2. **Head** is the vertical distance from the longitudinal to the deck at side, amidships.
3. **Corrections to Modulus of Longitudinals.**

FOR SPAN: If the span is $\frac{\text{greater}}{\text{less}}$ than 10 feet, modulus of longitudinals to be $\frac{\text{increased}}{\text{reduced}}$ at the rate of $\frac{20 \text{ per cent}}{15 \text{ per cent}}$ per foot of difference; the modulus is not to be less than that required for an 8 feet spacing of transverses.

LONGITUDINALS.
nd having a span of 10 feet.

TABLE 68

HEAD—FEET																			DEPTH
26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	D
← Modulus—Inches³ →																			Feet
																			16
																			17
																			18
																			19
																			20
																			21
																			22
																			23
																			24
																			25
																			26
																			27
33·2																			28
33·6	34·6																		29
34·1	35·1	36·1																	30
34·5	35·5	36·5	37·5																31
34·9	35·9	36·9	37·9	38·9															32
35·2	36·3	37·2	38·2	39·1	40·0														33
35·6	36·6	37·5	38·4	39·3	40·2	41·1													34
35·9	36·9	37·9	38·8	39·6	40·5	41·4	42·3												35
36·3	37·3	38·3	39·1	40·0	40·8	41·7	42·6	43·4											36
36·7	37·7	38·6	39·5	40·4	41·2	42·1	43·0	43·8	44·6										37
37·1	38·1	39·0	39·9	40·8	41·6	42·5	43·4	44·2	45·1	45·9									38
37·5	38·5	39·4	40·3	41·2	42·1	42·9	43·8	44·6	45·5	46·3	47·1								39
37·9	38·9	39·9	40·8	41·6	42·5	43·3	44·2	45·0	45·9	46·7	47·6	48·4							40
38·4	39·4	40·3	41·2	42·0	42·9	43·7	44·6	45·4	46·3	47·1	48·0	48·8	49·6						41
38·9	39·9	40·8	41·7	42·5	43·4	44·2	45·1	45·9	46·8	47·6	48·5	49·3	50·2	51·0					42
39·3	40·3	41·2	42·1	43·0	43·9	44·8	45·6	46·4	47·3	48·1	49·0	49·8	50·7	51·5	52·3				43
39·8	40·8	41·7	42·6	43·5	44·4	45·3	46·2	47·0	47·9	48·7	49·6	50·4	51·2	51·9	52·7	53·4			44
40·3	41·3	42·2	43·1	44·0	44·9	45·8	46·7	47·6	48·5	49·3	50·2	51·0	51·7	52·4	53·1	53·8	54·5		45
40·8	41·8	42·7	43·6	44·5	45·4	46·3	47·2	48·1	49·0	49·9	50·8	51·6	52·3	52·9	53·6	54·2	54·8	55·5	46

NOTES.—TABLE 68 (*continued*).

FOR SPACING OF LONGITUDINALS :

If the spacing of longitudinals differs from 30 inches the modulus is to be modified in direct proportion.

4. For minimum thickness of longitudinals *see* **Table 77.**

5. Particulars of sections and moduli are given in **Table 56.**

TABLE 69

Span o

DEPTH D	FRAME SPACING.	NUMBER OF STRINGERS.	MINIMUM DEPTH OF FRAMES.	HEAD—FEET															
				Not exceeding 6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
				<— Modulus—Inches³ —>															
Feet	Inches.		Inches.																
16	25	1	6	8·3	9·3	10·6	11·9	13·2	14·6	15·9									
17	25¼	1	6	8·4	9·4	10·7	12·0	13·4	14·7	16·0	17·4								
18	25½	1	6	8·5	9·5	10·8	12·1	13·5	14·9	16·2	17·6	18·9							
19	25¾	1	6	8·6	9·5	10·9	12·2	13·6	15·0	16·3	17·7	19·1	20·4	21·8					
20	26	1	6	8·7	9·6	11·0	12·3	13·7	15·1	16·5	17·9	19·2	20·6	22·0	23·4	24·7			
21	26¼	1	6	8·7	9·7	11·1	12·5	13·9	15·3	16·7	18·1	19·4	20·8	22·2	23·6	25·0	26·4		
22	26½	1	7	8·8	9·8	11·2	12·6	14·0	15·4	16·8	18·2	19·6	21·0	22·4	23·8	25·2	26·6	28·0	
23	26¾	1	7	8·9	9·9	11·3	12·7	14·2	15·6	17·0	18·4	19·8	21·2	22·7	24·1	25·5	26·9	28·3	29·7
24	27	1	7	9·0	10·0	11·4	12·9	14·3	15·7	17·2	18·6	20·0	21·4	22·9	24·3	25·7	27·1	28·6	30·0
25	27¼	2	7	9·0	10·1	11·5	13·0	14·4	15·9	17·3	18·8	20·2	21·6	23·1	24·5	26·0	27·4	28·9	30·3
26	27½	2	7	9·1	10·2	11·6	13·1	14·5	16·0	17·5	18·9	20·4	21·8	23·3	24·7	26·2	27·6	29·1	30·5
27	27¾	2	7	9·2	10·3	11·7	13·2	14·7	16·2	17·6	19·1	20·6	22·0	23·5	25·0	26·4	27·9	29·4	30·8
28	28	2	8	9·3	10·4	11·8	13·3	14·8	16·3	17·8	19·3	20·7	22·2	23·7	25·2	26·7	28·2	29·6	31·1
29	28¼	2	8	9·4	10·5	12·0	13·5	15·0	16·5	18·0	19·4	20·9	22·4	23·9	25·4	26·9	28·4	29·9	31·4
30	28½	2	8	9·5	10·2	10·8	11·7	13·1	14·4	15·7	17·0	18·3	19·6	20·9	22·2	23·5	24·8	26·1	27·4
31	28¾	2	8	9·6	10·3	10·9	11·8	13·2	14·5	15·8	17·1	18·4	19·8	21·1	22·4	23·7	25·0	26·3	27·7
32	29	2	9	9·7	10·4	11·0	11·9	13·3	14·6	15·9	17·2	18·6	19·9	21·2	22·5	23·9	25·2	26·6	27·9
33	29¼	2	9	9·7	10·4	11·1	12·0	13·4	14·7	16·1	17·4	18·7	20·1	21·4	22·7	24·1	25·4	26·8	28·1
34	29½	2	9	9·8	10·5	11·2	12·1	13·5	14·9	16·2	17·5	18·9	20·2	21·6	23·0	24·3	25·6	27·0	28·3
35	29¾	2	9	9·9	10·6	11·3	12·3	13·6	15·0	16·4	17·7	19·1	20·4	21·8	23·2	24·5	25·9	27·3	28·6
36	30	3	9	10·0	10·7	11·4	12·1	13·0	14·3	15·6	16·9	18·2	19·5	20·8	22·1	23·4	24·7	26·0	27·3
37	30¼	3	9	10·1	10·8	11·5	12·2	13·1	14·4	15·7	17·0	18·3	19·6	21·0	22·3	23·6	24·9	26·2	27·5
38	30½	3	10	10·2	10·9	11·6	12·4	13·2	14·5	15·8	17·2	18·5	19·8	21·1	22·5	23·8	25·1	26·4	27·7
39	30¾	3	10	10·3	11·0	11·7	12·5	13·3	14·6	16·0	17·3	18·6	20·0	21·3	22·6	24·0	25·3	26·6	28·0
40	31	3	10	10·3	11·1	11·8	12·6	13·4	14·8	16·1	17·4	18·8	20·1	21·5	22·8	24·2	25·5	26·8	28·2
41	31¼	3	10	10·4	11·2	11·9	12·7	13·5	14·9	16·2	17·6	18·9	20·3	21·6	23·0	24·3	25·7	27·0	28·4
42	31½	3	10	10·5	11·3	12·0	12·8	13·6	15·0	16·4	17·7	19·1	20·5	21·8	23·2	24·5	25·9	27·3	28·6
43	31¾	3	10	10·6	11·3	12·1	12·9	13·7	15·1	16·5	17·9	19·2	20·6	22·0	23·4	24·7	26·1	27·5	28·9
44	32	3	11	10·7	11·4	12·2	13·0	13·8	15·2	16·6	18·0	19·4	20·7	22·2	23·5	24·9	26·3	27·7	29·1
45	32¼	3	11	10·7	11·5	12·3	13·1	13·9	15·3	16·7	18·1	19·5	20·9	22·3	23·7	25·1	26·5	27·9	29·3
46	32½	3	11	10·8	11·6	12·4	13·2	14·1	15·5	16·9	18·3	19·7	21·1	22·5	23·9	25·3	26·7	28·1	29·5

WEB AT EVERY TRANSVERSE

NOTES.—TABLE 69.

1. **Span** is to be measured from stringer to stringer or from stringer to "span point" (*see* Sketch, page 239) of top or bottom bracket.
2. **Head** is the vertical distance from the mid-point of the span to the deck at side, at mid-length of tank.
3. **Corrections to Modulus of Frames.**

FOR SPAN: If the span is greater / less than 10 feet, modulus of frames to be increased by 25 per cent / reduced by 15 per cent per foot of difference.

FOR SPACING OF FRAMES: If the spacing differs from that given in the Table, modulus of frames to be modified in direct proportion.

IN CARGO TANKS.

10 feet.

TABLE 69

HEAD—FEET																		DEPTH
22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	D
<— Modulus—Inches³ —>																			Feet.
																			16
																			17
																			18
																			19
																			20
																			21
																			22
																			23
31·4																			24
31·7	33·2																		25
32·0	33·5	34·9																	26
32·3	33·8	35·2	36·7																27
32·6	34·1	35·6	37·0	38·5															28
32·9	34·4	35·9	37·4	38·9	40·4														29
28·7	30·0	31·3	32·6	33·9	35·2	36·5													30
29·0	30·3	31·6	32·9	34·2	35·5	36·9	38·2												31
29·2	30·5	31·8	33·2	34·5	35·8	37·1	38·5	39·8											32
29·4	30·8	32·1	33·5	34·8	36·1	37·5	38·8	40·1	41·5										33
29·7	31·0	32·4	33·7	35·1	36·5	37·8	39·2	40·5	41·9	43·2									34
30·0	31·3	32·7	34·0	35·4	36·8	38·2	39·5	40·9	42·2	43·6	45·0								35
28·6	29·9	31·2	32·5	33·8	35·1	36·4	37·7	39·0	40·3	41·6	42·9	44·2							36
28·8	30·1	31·4	32·7	34·0	35·4	36·7	38·0	39·3	40·6	41·9	43·2	44·5	45·8						37
29·0	30·4	31·7	33·0	34·3	35·7	37·0	38·3	39·6	40·9	42·2	43·6	44·9	46·2	47·5					38
29·3	30·6	32·0	33·3	34·6	36·0	37·3	38·6	39·9	41·3	42·6	43·9	45·3	46·6	47·9	49·2				39
29·5	30·9	32·2	33·5	34·9	36·2	37·6	38·9	40·2	41·6	42·9	44·3	45·6	47·0	48·3	49·6	51·0			40
29·8	31·1	32·5	33·8	35·2	36·5	37·9	39·2	40·6	41·9	43·3	44·6	46·0	47·3	48·7	50·0	51·4	52·8		41
30·0	31·4	32·7	34·1	35·5	36·8	38·2	39·5	40·9	42·3	43·6	45·0	46·4	47·7	49·1	50·4	51·8	53·2	54·5	42
30·2	31·6	33·0	34·4	35·7	37·1	38·5	39·9	41·3	42·6	44·0	45·4	46·7	48·1	49·5	50·8	52·2	53·6	55·0	43
30·5	31·9	33·2	34·6	36·0	37·4	38·8	40·2	41·6	42·9	44·3	45·7	47·1	48·5	49·9	51·2	52·6	54·0	55·4	44
30·7	32·1	33·5	34·9	36·3	37·7	39·1	40·5	41·9	43·2	44·6	46·0	47·4	48·8	50·2	51·6	53·0	54·4	55·8	45
30·9	32·3	33·8	35·2	36·6	38·0	39·4	40·8	42·2	43·6	45·0	46·4	47·8	49·2	50·6	52·0	53·4	54·8	56·2	46

NOTES.—TABLE 69 (*continued*).

4. When D is 30 feet or more the modulus given in the Table is that required if side transverses are fitted in conjunction with the bottom and deck transverses; if these are not fitted the modulus given in the Table is to be increased by 15 per cent. *See also* **Section 41, clause 1** (*e*).

5. For values of D between 29 and 30 feet and between 35 and 36 feet the Table modulus is to be extrapolated from the group appropriate to the arrangement of stringers and webs.

6. For minimum thickness of frames *see* **Table 77.**

7. Particulars of sections and moduli are given in **Table 56.**

NOT THE SAME AS CARGO SHIP BASIC DRAUGHT.

TABLE 70

SAME AS FOR CARGO SHIPS. TABLE 14.

SHELL AND STRENGT

LENGTH L	BASIC BREADTH B_b	BASIC DEPTH D_b	BASIC DRAUGHT d_b	SPACING OF TRANSVERSE SIDE FRAMING.	SPACING OF LONGITUDINAL FRAMING.	KEEL.		THICKNESS OF SHELL PLATING FOR ·5L AMIDSHIPS.			
								BOTTOM.		SIDE.	
						WIDTH.	THICKNESS.	WITH LONGITUDINAL FRAMING.	MINIMUM FOR TABLE SPACING OF LONGITUDINAL FRAMES.	WITH TRANSVERSE FRAMING.	WITH LONGITUDINAL FRAMING.
1	2	3	4	5	6	7	8	9	10	11	12
Feet.	Feet.	Feet.	Feet.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
240	40	19·0	14·4	24½	27	43	·65	·45	·45	·42	·41
250	41	19·75	15·0	24¾	27¼	43	·66	·46	·46	·43	·42
260	42	20·5	15·6	25	27½	44	·67	·47	·47	·44	·43
270	43	21·25	16·2	25¼	27¾	44	·69	·48	·48	·45	·44
280	44	22·0	16·8	25½	28	45	·70	·50	·50	·46	·45
290	45	22·75	17·4	25¾	28¼	45	·71	·51	·51	·47	·46
300	46	23·5	18·0	26	28½	46	·73	·52	·52	·48	·47
310	47	24·25	18·6	26¼	28¾	46	·75	·53	·53	·49	·48
320	48	25·0	19·2	26½	29	47	·76	·54	·54	·50	·49
330	49	25·75	19·8	26¾	29¼	47	·78	·55	·55	·51	·50
340	50	26·5	20·4	27	29½	48	·79	·56	·56	·52	·51
350	51	27·25	21·0	27¼	29¾	48	·80	·58	·57	·53	·52
360	52	28·0	21·6	27½	30	49	·82	·60	·58	·54	·53
370	53	28·75	22·2	27¾	30¼	49	·84	·62	·59	·55	·54
380	54	29·5	22·8	28	30½	50	·86	·63	·60	·56	·55
390	55	30·25	23·4	28¼	30¾	50	·88	·64	·61	·57	·56
400	56	31·0	24·0	28½	31	51	·89	·66	·62	·58	·57
410	57	31·75	24·6	28¾	31¼	51	·91	·68	·63	·59	·58
420	58	32·5	25·2	29	31½	52	·93	·69	·64	·60	·59
430	59	33·25	25·8	29¼	31¾	52	·94	·70	·65	·61	·60
440	60	34·0	26·4	29½	32	53	·96	·72	·66	·62	·61
450	61	34·75	27·0	29¾	32¼	53	·97	·74	·68	·63	·62
460	62	35·5	27·6	30	32½	54	·98	·76	·69	·64	·63
470	63	36·25	28·2	30¼	32¾	54	1·00	·78	·71	·65	·64
480	64	37·0	28·8	30½	33	55	1·02	·80	·73	·66	·65
490	65	37·75	29·4	30¾	33¼	55	1·03	·82	·75	·67	·66
500	66	38·5	30·0	31	33½	56	1·04	·84	·77	·69	·67
510	67	39·25	30·6	31¼	33¾	57	1·06	·86	·79	·70	·69
520	68	40·0	31·2	31½	34	57	1·07	·88	·81	·71	·70
530	69	40·75	31·8	31¾	34	58	1·09	·90	·83	·73	·71
540	70	41·5	32·1	32	34	59	1·11	·92	·85	·75	·72
550	72	42·25	32·4	32¼	34	59	1·12	·94	·87	·76	·73
560	74	43·0	32·7	32½	34	60	1·13	·97	·89	·77	·74
570	76	43·75	33·0	32¾	34	60	1·14	1·00	·91	·79	·76
580	78	44·5	33·3	33	34	61	1·15	1·03	·93	·80	·77
590	80	45·25	33·6	33¼	34	61	1·16	1·06	·95	·82	·78
600	82	46·0	33·9	33½	34	62	1·17	1·08	·97	·83	·80
610	83	46·75	34·2	33¾	34	63	1·18	1·11	·99	·84	·81
620	84	47·5	34·5	34	34	63	1·20	1·14	1·01	·85	·82

For Notes see page 216.

TABLE 70

DECK PLATING.

THICKNESS OF BOTTOM AND SIDE PLATING FOR ·05L FROM ENDS	WIDTH OF SHEER-STRAKE AND STRINGER PLATE FOR ·5L AMIDSHIPS.	THICKNESS OF SHEER-STRAKE FOR ·5L AMIDSHIPS.	WIDTH OF FLANGES OF STRINGER ANGLE FOR ·5L AMIDSHIPS.	STRENGTH DECK FOR ·5L AMIDSHIPS.					THICKNESS OF STRENGTH DECK FOR ·05L FROM ENDS.	BASIC AREA OF LONGITUDINALS PER FOOT OF BREADTH B.		LENGTH L
				SECTIONAL AREA.	*CORRECTION PER 1 FOOT DIFFERENCE BETWEEN:—*			MINIMUM THICKNESS.		BOTTOM.	DECK.	
					B *and* B_b	D *and* D_b	d *and* d_b					
13	14	15	16	17	18	19	20	21	22	23	24	25
Inches	Inches.	Inches.	Inches	Sq. Inches.	Per cent.	Per cent.	Per cent	Inches.	Inches.	Sq. Inches.	Sq. Inches.	Feet
·37	52	·58	6	48	*3·7*	*18·0*	*6·3*	·34	·29	1·80	·90	240
·37	52	·59	6	54	*3·6*	*17·0*	*6·2*	·34	·29	1·85	·90	250
·38	53	·61	6	60	*3·6*	*16·0*	*6·2*	·34	·29	1·90	·90	260
·38	53	·62	6	66	*3·5*	*15·0*	*6·1*	·35	·29	1·95	·95	270
·39	54	·64	6	72	*3·4*	*14·0*	*6·1*	·35	·30	2·00	·95	280
·39	54	·65	6	79	*3·3*	*13·0*	*6·0*	·35	·30	2·05	1·00	290
·40	55	·67	6	86	*3·3*	*12·0*	*6·0*	·36	·30	2·10	1·00	300
·40	55	·68	6	93	*3·2*	*11·0*	*5·9*	·36	·30	2·10	1·00	310
·41	56	·70	6	101	*3·2*	*10·0*	*5·9*	·37	·31	2·10	1·05	320
·41	56	·71	6	110	*3·1*	*9·5*	*5·8*	·37	·31	2·15	1·05	330
·42	57	·73	6	119	*3·0*	*9·0*	*5·8*	·38	·31	2·20	1·10	340
·42	57	·74	6	129	*2·9*	*8·5*	*5·7*	·39	·31	2·25	1·10	350
·43	58	·76	6	139	*2·9*	*8·0*	*5·7*	·40	·32	2·30	1·15	360
·43	58	·77	6	149	*2·8*	*7·6*	*5·6*	·41	·32	2·35	1·15	370
·44	59	·79	6	159	*2·8*	*7·4*	*5·6*	·42	·32	2·40	1·20	380
·44	59	·80	6	168	*2·7*	*7·2*	*5·5*	·43	·32	2·45	1·20	390
·45	60	·82	6	178	*2·6*	*7·0*	*5·5*	·44	·33	2·50	1·20	400
·45	60	·83	6	189	*2·6*	*6·8*	*5·4*	·45	·33	2·55	1·25	410
·46	61	·85	6	200	*2·5*	*6·6*	*5·4*	·46	·33	2·60	1·25	420
·46	61	·86	6	211	*2·4*	*6·4*	*5·3*	·47	·33	2·65	1·30	430
·47	62	·88	6	222	*2·4*	*6·2*	*5·3*	·48	·34	2·70	1·30	440
·47	62	·90	7	234	*2·3*	*6·0*	*5·2*	·49	·34	2·75	1·30	450
·48	63	·92	7	247	*2·2*	*5·9*	*5·1*	·50	·34	2·80	1·35	460
·48	63	·93	7	261	*2·2*	*5·8*	*5·0*	·52	·34	2·85	1·35	470
·49	64	·95	7	275	*2·1*	*5·7*	*4·9*	·54	·34	2·90	1·35	480
·49	64	·96	7	290	*2·1*	*5·6*	*4·8*	·55	·34	3·00	1·40	490
·50	65	·98	7	306	*2·0*	*5·5*	*4·7*	·56	·35	3·10	1·40	500
·50	65	·99	7	322	*1·9*	*5·4*	*4·6*	·58	·35	3·15	1·40	510
·51	66	1·01	7	338	*1·9*	*5·3*	*4·5*	·60	·35	3·20	1·45	520
·51	66	1·02	7	354	*1·8*	*5·2*	*4·4*	·61	·35	3·25	1·45	530
·52	67	1·04	7	370	*1·8*	*5·1*	*4·3*	·62	·35	3·30	1·45	540
·52	67	1·06	7	393	*1·7*	*5·0*	*4·2*	·64	·35	3·35	1·50	550
·53	68	1·08	8	417	*1·7*	*4·8*	*4·1*	·66	·36	3·40	1·50	560
·53	68	1·11	8	441	*1·7*	*4·6*	*3·9*	·67	·36	3·45	1·50	570
·54	69	1·14	8	465	*1·6*	*4·5*	*3·7*	·68	·36	3·50	1·55	580
·55	69	1·16	8	490	*1·6*	*4·4*	*3·6*	·69	·36	3·55	1·55	590
·56	70	1·18	8	514	*1·6*	*4·2*	*3·5*	·70	·36	3·60	1·60	600
·56	71	1·21	8	534	*1·6*	*4·1*	*3·4*	·71	·36	3·65	1·60	610
·57	72	1·24	8	554	*1·5*	*4·0*	*3·4*	·72	·37	3·70	1·60	620

For Notes see page 216.

TABLE 70

(SEE PAGES 34 & 35.)

SHELL AND STRENGTH DECK PLATING.

NOTES.—TABLE 70.

1. **Keel.**—The width and thickness of the keel plate (Cols. 7 & 8) are to be maintained throughout; the thickness is not to be reduced if the width is greater than required.

2. **Bottom Plating** (from keel to upper turn of bilge).

(*a*) The Table thickness (Col. 9) is to be corrected, if necessary, as follows:—

FOR DEPTH.

If D is $\frac{\text{greater}}{\text{less}}$ than D_b, thickness to be $\frac{\text{reduced}}{\text{increased}}$ by 0·7 per cent per foot of difference.

FOR DRAUGHT.

If d is $\frac{\text{greater}}{\text{less}}$ than d_b, the thickness, after correction for depth where necessary, is to be $\frac{\text{increased}}{\text{reduced}}$ by 1·5 per cent. per foot of difference.

(*b*) If the seams are riveted the thickness corrected as above may be reduced by 6 per cent.

(*c*) If the area of the bottom longitudinals per foot of breadth B is $\frac{\text{greater}}{\text{less}}$ than the basic area in Col. 23 (and *see* Note 9 below) the thickness is to be $\frac{\text{reduced}}{\text{increased}}$ at the rate of ·01 inch for every ·15 square inch of difference in area per foot of bottom longitudinals.

(*d*) If the spacing of longitudinals differs from that given in Col. 6 the corrected thickness of plating is to be modified at the rate of ·01 inch for every inch of difference.

(*e*) The minimum thickness amidships (Col. 10) is to be corrected for spacing of longitudinals only.

3. **Side Plating** (from upper turn of bilge to lower edge of sheerstrake).

The Table thickness (Cols. 11 or 12) is to be corrected, if necessary, as required for bottom plating by Note 2(*a*) above.

If the spacing of transverse or longitudinal framing differs from that given in Col. 5 or 6, the corrected thickness is to be modified at the rate of ·01 inch per inch of difference.

Notes 2(*b*) and (*c*) do not apply to side plating.

4. **Shell Plating at Ends.**—The thickness of side and bottom plating is to taper gradually from the midship thickness (Cols. 9 to 12) to the end thickness (Col. 13), except as qualified by **Section 47, clause 3**(*d*).

The thickness in Col. 13 is not subject to corrections for depth and draught.

5. **Sheerstrake.**—(*a*) The Table thickness (Col. 15) is to be corrected if necessary, as follows:—

FOR DEPTH.

If D is $\frac{\text{greater}}{\text{less}}$ than D_b, thickness to be $\frac{\text{reduced}}{\text{increased}}$ by 4 per cent per foot of difference.

FOR DRAUGHT.

If d is $\frac{\text{greater}}{\text{less}}$ than d_b, the thickness, after correction for depth where necessary, is to be $\frac{\text{increased}}{\text{reduced}}$ by 4 per cent per foot of difference.

(*b*) The thickness of the sheerstrake is not to be corrected for frame spacing. At the ends the thickness is to be the same as that of the side plating.

6. **Stringer Angle.**—The width of flanges of the stringer angle is given in Col. 16. The thickness is to be that of the stringer plate or sheerstrake whichever is less. *See also* **Section 44, clause 1**(*c*).

7. **Stringer Plate.**—The width for ·5L amidships is given is Col. 14, and for ·05L at ends is not to be less than 60 per cent of that width.

The thickness is not to be less than 85 per cent of the sheerstrake, corrected as required by Note 5, and not less than ·04 greater than that given in Col. 21.

8. **Strength Deck Plating.**—(*a*) The area given in Col. 17 is the sectional area of deck plating including stringer plate and stringer angle on one side of the ship abreast openings. If riveted overlapped seams are fitted they may be included in determining the required deck thickness.

(*b*) The Table area is to be corrected, if necessary as follows:—

FOR BREADTH.

If B is $\frac{\text{greater}}{\text{less}}$ than B_b, area to be $\frac{\text{increased}}{\text{reduced}}$ by the given percentage (Col. 18) per foot of difference.

FOR DEPTH.

If D is $\frac{\text{greater}}{\text{less}}$ than D_b, area, after correction for breadth where necessary, to be $\frac{\text{reduced}}{\text{increased}}$ by the given percentage (Col. 19) per foot of difference.

FOR DRAUGHT.

If d is $\frac{\text{greater}}{\text{less}}$ than d_b, area, after correction for depth and breadth when necessary, to be $\frac{\text{increased}}{\text{reduced}}$ by the given percentage (Col. 20) per foot of difference.

(*c*) If the area of deck longitudinals abreast openings per foot of breadth B is $\frac{\text{greater}}{\text{less}}$ than the basic area in Col. 24 (and *see* Note 9 below) the thickness of the stringer and deck plating is to be $\frac{\text{reduced}}{\text{increased}}$ at the rate of ·01 inch for every ·15 square inch of difference in area.

If after the above correction the thickness of the stringer plate requires to be increased to comply with Note 7 the total area of deck plating and stringer is to be maintained.

(*d*) If the spacing of longitudinals differs from that given in Col. 6 the minimum thickness of deck plating for ·5L amidships (Col. 21) is to be modified at the rate of ·01 inch for every 2 inches of difference.

(*e*) The thickness of deck plating is to taper gradually from the midship thickness to the end thickness (Col. 22), except as qualified by **Section 45, clause 2**(*a*) & (*b*).

9. **Area of Longitudinals.**—The basic area of bottom and deck longitudinals (Cols. 23 and 24) is the sectional area of longitudinals per foot of breadth B for a 10 ft. spacing of transverse supports. The total area of bottom longitudinals is to include those at the bilge and longitudinal bulkheads up to ·1D from the base line. The total area of deck longitudinals is to include those at ship's side and at longitudinal bulkhead down to ·1D from the deck line at side.

If the spacing of transverses is $\frac{\text{greater}}{\text{less}}$ than 10 feet the basic area is to be $\frac{\text{increased by 10 per cent}}{\text{reduced by 5 per cent}}$ for every foot of difference.

TABLE 71

BULKHEAD PLATING.

LENGTH L	SPACING OF HORIZONTAL OR VERTICAL STIFFENERS.	TOP STRAKE OF LONGITUDINAL BULKHEAD.	BOTTOM STRAKE OF LONGITUDINAL BULKHEAD.	DEPTH. FEET.							
				Not exceeding 18	22	26	30	34	38	42	46
Feet.	Inches.	Inches.	Inches.	<—— Inches. ——>							
240	27	·34	·38	·34							
260	27	·34	·38	·34							
280	27	·34	·39	·34							
300	28	·36	·40	·36	·38						
320	28	·38	·41	·38	·38						
340	29	·38	·42	·38	·39						
360	29	·39	·44	·39	·40	·42					
380	30	·42	·46	·40	·41	·43					
400	30	·43	·48	·41	·42	·43	·45				
420	30	·43	·50	·41	·42	·43	·45				
440	30	·44	·51	·42	·42	·43	·45	·47			
460	30	·45	·52	·42	·42	·44	·46	·48	·50		
480	30	·46	·53	·42	·42	·44	·46	·48	·50		
500	30	·47	·54	·42	·42	·44	·46	·48	·50	·52	
520	30	·48	·55	·42	·42	·44	·46	·48	·50	·52	
540	30	·49	·56	·42	·42	·44	·46	·48	·50	·52	·54
560	30	·50	·57	·43	·43	·44	·46	·48	·50	·52	·54
580	30	·51	·58	·43	·43	·44	·46	·48	·50	·52	·54
600	30	·52	·58	·44	·44	·44	·46	·48	·50	·52	·54
620	30	·53	·59	·44	·44	·44	·46	·48	·50	·52	·54

NOTES.—TABLE 71.

1. **Depth** is to be measured from the highest point of the tank, excluding the hatchway, to the lower edge of the plate, whether the plating is arranged in vertical or horizontal strakes.

2. **Correction for Spacing of Stiffeners.**—If the spacing of stiffeners differs from the Table spacing, the thickness of the plating, including top and bottom strakes, is to be modified at the rate of 2 per cent for every inch of difference.

3. The width of the top and bottom strakes is not to be less than ·15 D.

TABLE 72

BULKHEAD STIFFENERS.

Spaced 30 inches apart and having a span of 10 feet.

HEAD.	MODULUS OF STIFFENER.	HEAD.	MODULUS OF STIFFENER.
Feet.	Inches³.	Feet.	Inches³.
4	8·5	23	29·8
5	9·2	24	31·1
6	10·0	25	32·3
7	10·7	26	33·6
8	11·4	27	34·8
9	12·2	28	36·0
10	13·0	29	37·1
11	14·3	30	38·2
12	15·6	31	39·2
13	16·9	32	40·1
14	18·2	33	41·0
15	19·5	34	41·9
16	20·8	35	42·7
17	22·1	36	43·6
18	23·4	37	44·4
19	24·7	38	45·3
20	26·0	39	46·2
21	27·3	40	47·1
22	28·6		

NOTES—TABLE 72.

1. **Span** is to be measured from web to web or girder to girder or from web or girder to the "span point" (*see* Sketch, page 239) on the end connection.

2. **Head** is the vertical distance from the centre of the span to the highest point of the tank, excluding the hatchway.

3. **Corrections to Modulus of Stiffeners.**

FOR SPAN :

If the span is $\frac{\text{greater}}{\text{less}}$ than 10 feet, modulus to be $\frac{\text{increased}}{\text{decreased}}$ at the rate of $\frac{25 \text{ per cent}}{18 \text{ per cent}}$ per foot of difference.

FOR SPACING OF STIFFENERS :

If the spacing of stiffeners differs from 30 inches the modulus is to be modified in direct proportion.

4. The modulus of horizontal stiffeners on longitudinal bulkheads is not to be less than 90 per cent of the modulus of the uppermost side longitudinal.

5. The modulus of longitudinal bulkhead vertical stiffeners may be reduced, after correction as required by Note 3, by 10 per cent. if verticle webs are fitted.

6. For minimum thickness of stiffeners *see* **Table 77.**

7. Particulars of sections and moduli are given in **Table 56.**

TABLE 73

FLOORS AT FORE END.

DEPTH D	FLOOR PLATE.		FACE AREA	DEPTH D	FLOOR PLATE.		FACE AREA
	DEPTH	THICKNESS			DEPTH	THICKNESS	
Feet.	Inches.	Inches.	Sq. Inches.	Feet	Inches.	Inches.	Sq. Inches.
16	20	·31	0·6	32	40	·42	2·2
18	22	·33	0·8	34	43	·43	2·4
20	25	·34	1·0	36	46	·44	2·6
22	28	·36	1·2	38	48	·45	2·8
24	30	·37	1·4	40	50	·47	3·0
26	33	·39	1·6	42	52	·48	3·2
28	36	·40	1·8	44	54	·49	3·4
30	38	·41	2·0	46	56	·51	3·6

NOTES.—TABLE 73.

1. **Depth** given in the Table is the depth of the floor plate at the centre line.

2. **Correction for Spacing.**

If the spacing of floors differs from 27 inches or the spacing required for transverse frames in **Table 12**, whichever is less, the thickness is to be modified at the rate of ·01 inch for every two inches of difference.

TABLE 74

BOTTOM PLATING FORWARD.

LENGTH L	THICKNESS (with Welded seams, Longitudinals & Floors.)		REDUCTION IN THICKNESS IF SEAMS, LONGITUDINALS & FLOORS RIVETED.	
	At Longl. Framing.	At Trans. Framing.		Inches.
Feet. 250	·50	·50	LENGTH NOT EXCEEDING **500** Feet.	0·04
300	·55	·54		
350	·61	·59		
400	·68	·65		
450	·75	·71		
500	·81	·76	LENGTH ABOVE **500** Feet & NOT EXCEEDING **550** Feet.	0·02
550	·87	·82		
600 AND ABOVE.	·94	·88	LENGTH EXCEEDING **550** Feet.	0

NOTES.—TABLE 74.

1. The thickness of bottom plating forward is not to be less at any point than would be required for the normal taper from midship to end thickness by **Table 70.**

See also **Section 47, clause 3** (*d*).

2. **Correction for Spacing.**

If the spacing of floors differs from 27 inches or that given in Col. 5 of **Table 70,** whichever is less, or the spacing of longitudinals differs from that given in Col. 6, **Table 70,** the thickness of the plating is to be modified at the rate of ·01 inch per inch of difference.

TABLE 75

WEB FRAMES AND SIDE STRINGERS AT FORE END.

Web frames spaced 9 ft. apart supporting one side stringer.

DEPTH D	**h** - FEET									
	8	10	12	14	16	18	20	22	24	26
	FACE AREA IN SQUARE INCHES.									
	1·5	2	3	4	5	6	7	8	9	10
Feet.	DEPTH AND THICKNESS OF WEB PLATE IN INCHES.									
16	12×·36	14×·36	14×·36	15×·36	15×·36	16×·38				
18	13×·36	14×·36	15×·36	16×·36	17×·36	17×·38	18×·38			
20	13×·36	15×·36	16×·36	17×·36	18×·38	19×·38	19×·38	20×·40		
22	14×·36	16×·36	17×·36	17×·38	19×·38	20×·38	20×·40	21×·40	22×·40	
24	14×·36	16×·38	18×·38	18×·38	20×·38	21×·40	22×·40	23×·40	23×·42	24×·42
26	14×·38	17×·38	19×·38	19×·38	21×·38	22×·40	23×·40	24×·42	25×·42	26×·42
28	15×·38	18×·38	19×·38	20×·38	22×·40	23×·40	24×·42	25×·42	26×·42	27×·44
30	15×·38	18×·38	20×·38	21×·38	23×·40	24×·40	25×·42	27×·42	28×·42	29×·44
32	16×·38	19×·38	20×·38	22×·40	23×·40	25×·42	26×·42	28×·42	29×·44	30×·44
34	16×·38	19×·40	21×·40	23×·40	24×·40	26×·42	27×·42	29×·44	30×·44	31×·46
36	17×·38	20×·40	22×·40	24×·40	25×·42	27×·42	29×·44	30×·44	31×·44	33×·46
38		20×·40	23×·40	24×·40	26×·42	28×·42	30×·44	31×·44	33×·46	34×·46
40		21×·40	23×·40	25×·42	27×·42	29×·44	31×·44	32×·46	34×·46	35×·48
42		21×·40	24×·40	25×·42	27×·44	30×·44	32×·46	33×·46	35×·48	37×·48
44			24×·42	26×·42	28×·44	30×·44	32×·46	34×·46	36×·48	38×·48
46				27×·44	29×·44	31×·46	33×·46	35×·48	37×·48	39×·48

NOTES.—TABLE 75.

1. **Depth** of Web Frames and Stringers given in the Table is the depth of the web plate.

Thickness of plates of web frames or stringers is to be the thickness indicated in the Table for the depth of web corrected as below at the appropriate depth D.

2. (*a*)—**h** in deep tanks is to be measured at the mid-length of the tank from the top of floors to the tank top at side.

In tanks of unusual depth, **h** may be measured to a suitable side stringer (*see* **Section 47, clause 5**) provided the strength of this stringer, and of the supporting webs, is adequately increased.

(*b*) **h** above the deep tank is to be measured at the mid-length of the hold from the tank top to the lowest deck at side.

3. **Web Frames in Deep Tanks.**—The following corrections are to be made if necessary to the Table depth :

For Spacing of Web Frames.

If the spacing of web frames differs from 9 feet, the depth of web is to be modified at the rate of 7 per cent for every foot of difference.

For Number of Stringers.

If two stringers are supported, the depth, after correction for spacing if necessary, is to be increased by 12½ per cent ; if three stringers are supported, the depth is to be increased by 20 per cent.

4. **Side Stringers in Deep Tanks.**—The following corrections are to be made if necessary to the Table depth :

For Spacing of Web Frames.

If the spacing of web frames differs from 9 feet, the depth of stringers is to be modified at the rate of 15 per cent per foot of difference.

For Number of Stringers.

The Table depth, after correction for spacing if necessary, may be reduced as follows :—

If one stringer is fitted, 15 per cent
„ two stringers are „ 30 per cent
„ three „ „ „ 40 per cent

The edge of stringer plates is to be stiffened by a 3½ inch flange, or equivalent.

5. **Web Frames in the Hold above Deep Tanks.**—The depth of web frames in the hold is to be 80 per cent of the depth obtained from the Table after the following corrections have been made :

For Spacing of Web Frames.

Depth to be modified if necessary as required by Note 3 above.

For Number of Stringers, or for 'Tween Decks.

If more than one stringer is supported, the depth, after correction for spacing if necessary, is to be increased by 12½ per cent ; if there is a 'tween deck (excluding forecastle) above the hold the depth is to be increased by 20 per cent.

The face area may be 80 per cent of the Table area.

6. **Side Stringers in Hold above Deep Tanks.**—The depth of stringers is to be 75 per cent of the corrected depth of web frames carrying one stringer. The edge of stringer plates is to be flanged or otherwise suitably stiffened.

TABLE 76
(SEE CONTINUATION.)

WELDING AND RIVETING.

A.

TYPES OF WELDING.

SIZE OF FILLET WELDS.

PLATING THICKNESS.	LEG LENGTH.		
	Type 1.	Type 2.	Type 3.
Inches.	Inches.	Inches.	Inches.
·20	·22	·18	·18
·30	·26	·20	·18
·40	·30	·24	·18
·50	·34	·28	·22
·60	·38	·32	·26

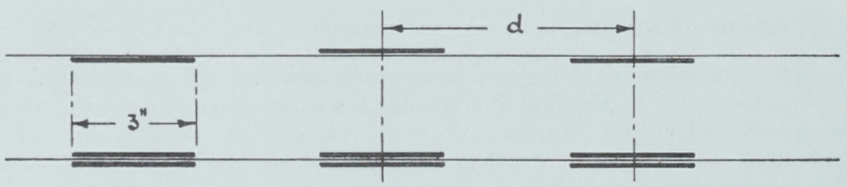
NOTES.—TABLE 76 (A).

1. **Size of fillet** is the minimum length of leg. The throat thickness of the weld is to be 70 per cent of the leg length.
2. **Leg length** is to be governed by the thickness of the abutting plate or web. Where the difference between the thickness of the parts to be joined is considerable the size of the fillet will be specially considered.
3. Leg lengths for intermediate thicknesses to be obtained by direct interpolation.
4. **Minimum leg length** of fillet weld to be ·18 inch.

INTERMITTENT FILLET WELDS.

STAGGERED INTERMITTENT (S)
(Type 1).

CHAIN INTERMITTENT (C)
(Type 1).



SCALLOPED STIFFENERS WITH DOUBLE FILLET WELDS.
Type as per Table 76 (H).
Welding to be carried round the end of all lugs.

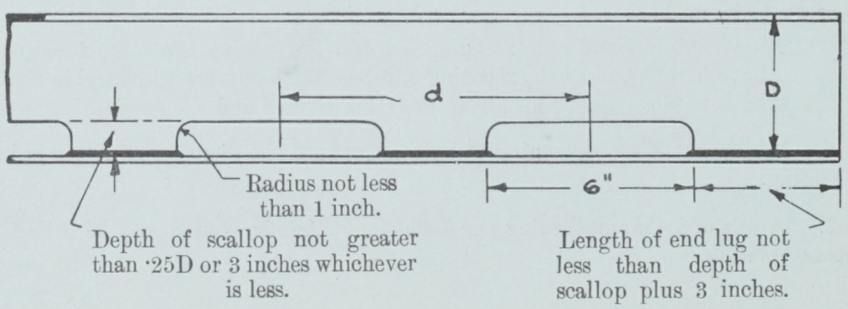


TABLE 76

(SEE CONTINUATION.)

WELDING AND RIVETING.

B.

RIVETING OF END LAPS AND SEAMS OF SHELL PLATING.

ITEM.	THICKNESS.		END LAPS AND BUTT STRAPS.					SEAMS.		
	Above.	Not exceeding.	Diameter of Rivets	Type.	Breadth. End Lap.	Breadth. Butt Strap.	Spacing of Rivets, Centre to Centre.	Type.	Breadth.	Spacing of Rivets, Centre to Centre.
	Inches.	Inches.	Inches.		Inches.	Inches.	Inches.		Inches.	Inches.
Sheerstrake for ·5L amidships		·50	$\frac{3}{4}$	Treble	$7\frac{1}{2}$	$14\frac{1}{4}$	$2\frac{5}{8}$	*See* Note 3		
	·50	·60	$\frac{7}{8}$	Treble	9	$16\frac{3}{4}$	$3\frac{1}{8}$			
	·60	·72	$\frac{7}{8}$	Quadruple	12	22	$3\frac{1}{2}$			
	·72	·84	1	Quadruple	14	25	4			
	·84	·94	1	Quintuple	$17\frac{1}{2}$		$4\frac{1}{2}$			
	·94	1·14	$1\frac{1}{8}$	Quintuple	20		5			
	1·14	1·26	$1\frac{1}{4}$	Quintuple	$22\frac{1}{2}$		$5\frac{5}{8}$			
Bottom Plating from keel to upper turn of bilge for ·5L amidships		·50	$\frac{3}{4}$	Treble	$7\frac{1}{2}$	$14\frac{1}{4}$	$2\frac{5}{8}$	Double	$4\frac{1}{2}$	$2\frac{5}{8}$
	·50	·60	$\frac{7}{8}$	Treble	9	$16\frac{3}{4}$	$3\frac{1}{8}$	Double	$5\frac{1}{4}$	$3\frac{1}{2}$
	·60	·72	$\frac{7}{8}$	Quadruple	12	22	$3\frac{1}{2}$	Double	$5\frac{1}{4}$	$3\frac{1}{2}$
	·72	·94	1	Quadruple	14	25	4	Double	6	4
	·94	1·14	$1\frac{1}{8}$	Quintuple	20		5	Double	$6\frac{3}{4}$	$4\frac{1}{2}$
Sheerstrake at ends Side shell plating from upper turn of bilge to sheerstrake. Bottom Plating from keel to upper turn of bilge at ends.		·42	$\frac{3}{4}$	Double	5	$9\frac{3}{4}$	$2\frac{5}{8}$	Double	$4\frac{1}{2}$	$2\frac{5}{8}$
	·42	·50	$\frac{3}{4}$	Treble	$7\frac{1}{2}$	$14\frac{1}{4}$	$2\frac{5}{8}$	Double	$4\frac{1}{2}$	$2\frac{5}{8}$
	·50	·68	$\frac{7}{8}$	Treble	9	$16\frac{3}{4}$	$3\frac{1}{8}$	Double	$5\frac{1}{4}$	$3\frac{1}{2}$
	·68	·72	$\frac{7}{8}$	Quadruple	12	22	$3\frac{1}{2}$	Double	$5\frac{1}{4}$	$3\frac{1}{2}$
	·72	·94	1	Quadruple	14	25	4	Double	6	4
Keel.		·72	$\frac{7}{8}$	Quadruple	12	22	$3\frac{1}{2}$	*See* Note 3		
	·72	·84	1	Quadruple	14	25	4			
	·84	·94	1	Quintuple	$17\frac{1}{2}$		$4\frac{1}{2}$			
	·94	1·14	$1\frac{1}{8}$	Quintuple	20		5			
	1·14	1·26	$1\frac{1}{4}$	Quintuple	$22\frac{1}{2}$		$5\frac{5}{8}$			

See Notes 2, 4 & 5

NOTES.—TABLE 76 (B).

1. Treble riveted double butt straps may be fitted as an alternative to quintuple riveted end laps, the rivet spacing being as given in the Table.

2. The number of rows of rivets in seams all fore and aft is to be regulated by the thickness of plating amidships (except as covered by Note 5).

3. In seams of keel and sheerstrake the diameter of rivets and type of seam are to be regulated by the thickness of the adjacent plating.

4. For number of rivets between transverse frames in seams of side plating *see* **Table 76 (D)**. Where the form of the ship, forward and aft, is curved, or where longitudinal side framing is adopted, the spacing of the rivets is not to exceed $3\frac{1}{2}$ diameters where the thickness of plating does not exceed ·50 inch and 4 diameters where the thickness exceeds ·50 inch. Clear of cargo tanks the spacing of rivets in seams of sheerstrake, side and bottom plating is not to exceed $4\frac{1}{2}$ diameters and in end laps the spacing is not to exceed 4 diameters. (For special requirements for ships above 500 feet, *see* Note 5.)

5. In ships above 500 feet in length in the three seams nearest the neutral axis and for three-quarters of the length amidships the following additions are to be made :—

Above 500 feet and not exceeding 525 feet the spacing is not to exceed $3\frac{1}{2}$ diameters.
Above 525 feet and not exceeding 550 feet the seams are to be treble riveted and the spacing is not to exceed 4 diameters.
Above 550 feet the seams are to be treble riveted and the spacing is not to exceed $3\frac{1}{2}$ diameters.

6. In way of the strengthening of bottom forward the diameter of rivets in butts and seams is to be appropriate to the increased thickness of the plating.

7. In way of ice strengthening the diameter of the rivets used may be $\frac{1}{8}$ inch less than that required by **Table 52 (A)** for the increased thickness of plating.

TABLE 76

(SEE CONTINUATION.)

WELDING AND RIVETING.

C.

RIVETING OF END LAPS AND SEAMS OF DECK PLATING.

ITEM.	THICKNESS.		END LAPS AND BUTT STRAPS.					SEAMS		
	Above.	Not exceeding.	Diameter of Rivets.	Type.	Breadth.		Spacing of Rivets. Centre to Centre.	Type.	Breadth.	Spacing of Rivets. Centre to Centre.
					End Lap.	Butt Strap.				
	Inches.	Inches.	Inches.		Inches.	Inches.	Inches.		Inches.	Inches.
Strength deck stringer plate for ·5L amidships.		·50	$\frac{3}{4}$	Treble	$7\frac{1}{2}$	$14\frac{1}{4}$	$2\frac{5}{8}$	*See* Note **2**		
	·50	·60	$\frac{7}{8}$	Treble	9	$16\frac{3}{4}$	$3\frac{1}{8}$			
	·60	·72	$\frac{7}{8}$	Quadruple	12	22	$3\frac{1}{2}$			
	·72	·84	1	Quadruple	14	25	4			
	·84	·94	1	Quintuple	$17\frac{1}{2}$		$4\frac{1}{2}$			
	·94	1·14	$1\frac{1}{8}$	Quintuple	20		5			
	1·14	1·26	$1\frac{1}{4}$	Quintuple	$22\frac{1}{2}$		$5\frac{5}{8}$			
Strength deck stringer plate at ends.		·42	$\frac{3}{4}$	Double	5	$9\frac{3}{4}$	$3\frac{3}{8}$	*See* Note **2**		
	·42	·50	$\frac{3}{4}$	Treble	$7\frac{1}{2}$	$14\frac{1}{4}$	$3\frac{3}{8}$			
	·50	·68	$\frac{7}{8}$	Treble	9	$16\frac{3}{4}$	4			
	·68	·72	$\frac{7}{8}$	Quadruple	12	22	4			
	·72	·94	1	Quadruple	14	25	$4\frac{1}{2}$			
Strength deck plating for ·5L amidships.		·48	$\frac{3}{4}$	Double	5	$9\frac{3}{4}$	$2\frac{5}{8}$	Double	$4\frac{1}{2}$	$2\frac{5}{8}$
	·48	·50	$\frac{3}{4}$	Treble	$7\frac{1}{2}$	$14\frac{1}{4}$	$2\frac{5}{8}$	Double	$4\frac{1}{2}$	$2\frac{5}{8}$
	·50	·68	$\frac{7}{8}$	Treble	9	$16\frac{3}{4}$	$3\frac{1}{8}$	Double	$5\frac{1}{4}$	$3\frac{1}{2}$
	·68	·72	$\frac{7}{8}$	Quadruple	12	22	$3\frac{1}{2}$	Double	$5\frac{1}{4}$	$3\frac{1}{2}$
	·72	·94	1	Quadruple	14	25	4	Double	6	4
	·94	1·14	$1\frac{1}{8}$	Quintuple	20		5	Double	$6\frac{3}{4}$	$4\frac{1}{2}$
	1·14	1·26	$1\frac{1}{4}$	Quintuple	$22\frac{1}{2}$		$5\frac{5}{8}$	Double	$7\frac{1}{2}$	5
Strength deck plating at ends.		·50	$\frac{3}{4}$	Double	5	$9\frac{3}{4}$	$3\frac{3}{8}$	Double	$4\frac{1}{2}$	$2\frac{5}{8}$ *See* Note **4**
	·50	·54	$\frac{7}{8}$	Double	6	$11\frac{1}{4}$	4	Double	$5\frac{1}{4}$	$3\frac{1}{2}$
	·54	·72	$\frac{7}{8}$	Treble	9	$16\frac{3}{4}$	4	Double	$5\frac{1}{4}$	$3\frac{1}{2}$
	·72	·94	1	Treble	$10\frac{1}{2}$	19	$4\frac{1}{2}$	Double	6	4
Strength deck stringer angles.	*See* Note **3**									

NOTES.—TABLE 76 (C).

1. Treble riveted double butt straps may be fitted as an alternative to quintuple riveted end laps, the rivet spacing being as given in the Table.

2. In seams of stringer plates the diameter of rivets and number of rows are to be regulated by the thickness of the adjacent deck plating.

3. The stringer angle is to be double riveted over the cargo tanks and for $\frac{1}{3}$B into the poop. The diameter of the rivets is to be governed by the thickness of the angle and the rivets are to be spaced 5 diameters apart in each row. At the ends of the ship the riveting is to be in accordance with **Table 19.**

4. The seams of strength deck plating at ends clear of oil tanks may be single riveted.

TABLE 76

(SEE CONTINUATION)

WELDING AND RIVETING.

D.

NUMBER OF RIVETS IN SEAMS OF SIDE SHELL PLATING BETWEEN TRANSVERSE FRAMES EXCLUDING RIVETS IN FRAMES.

FRAME SPACING.	THICKNESS OF SIDE SHELL IN INCHES.		
	Not exceeding ·50	Above ·50 and not exceeding ·72	Above ·72 and not exceeding ·94
	DIAMETER OF RIVET IN INCHES.		
	$\frac{3}{4}$	$\frac{7}{8}$	1
	NUMBER OF RIVETS IN EACH ROW.		
Inches.			
24	8	6	
$24\frac{1}{2}$	8	6	
25	9	6	
$25\frac{1}{2}$	9	7	
26	9	7	6
$26\frac{1}{2}$	9	7	6
27	9	7	6
$27\frac{1}{2}$	10	7	6
28	10	7	6
$28\frac{1}{2}$	10	7	6
29	10	8	7
$29\frac{1}{2}$	10	8	7
30	11	8	7
$30\frac{1}{2}$	11	8	7
31	11	8	7
$31\frac{1}{2}$	11	8	7
32	11	8	7
$32\frac{1}{2}$		8	8
33		9	8
$33\frac{1}{2}$		9	8
34		9	8
$34\frac{1}{2}$		9	8
35		9	8
$35\frac{1}{2}$		9	8
36		9	8

NOTES.—TABLE 76 (D).

1. For spacing of rivets clear of cargo tanks and where the form of the ship is curved *see* **Table 76 (B)**, Note 4.

2. For special requirements in ships above 500 feet in length *see* **Table 76 (B)**, Note 5.

TABLE 76
(SEE CONTINUATION.)

WELDING AND RIVETING.

E.

CONNECTIONS OF LONGITUDINALS, FRAMES AND STIFFENERS TO STIFFENING BARS ON PRIMARY SUPPORTING MEMBERS.

SECTION MODULUS OF LONGITUDINAL FRAME OR STIFFENER.		CONNECTIONS.		
		WELDED.	RIVETED.	
		AREA.	NUMBER.	DIAMETER.
Inches³ Above	Not exceeding	Square Inches.		Inches.
	15	2·0	4	$\frac{3}{4}$
15	25	2·75	4	$\frac{7}{8}$
25	35	3·5	5	$\frac{7}{8}$
35	50	4·0	6	$\frac{7}{8}$
50	70	4·75	7	$\frac{7}{8}$
70	90	5·5	8	$\frac{7}{8}$
90	125	6·25	9	$\frac{7}{8}$

NOTES.—TABLE 76 (E).

1. **Area of weld** is the product of the throat thickness and the total length of weld. The throat thickness is not to be less than 70 per cent of the leg length for a Type 1 weld. (*See* **Table 76 (A).**)

2. The area of weld and number of rivets given in the Table are for bottom and side transverses; for deck transverses the area of weld or number of rivets is not to be less than half the Table value.

3. **Number of rivets** given in the Table (or as modified by Note 2) is the minimum; the number fitted is to be sufficient to close the work satisfactorily.

F.

BRACKETS AT HEAD OF SIDE FRAMES AND AT ENDS OF VERTICAL STIFFENERS TO LONGITUDINAL BULKHEADS.

DEPTH OF FRAME OR STIFFENER.	BRACKETS.			CONNECTIONS.		
				WELDED.	RIVETED.	
	LENGTH OF ARM.	THICKNESS.	WIDTH OF FLANGE.	AREA.	NUMBER.	DIAMETER.
Inches.	Inches.	Inches.	Inches.	Square Inches.		Inches.
6	16	·36		2·5	5	$\frac{3}{4}$
7	18	·36	$2\frac{1}{2}$	3·0	6	$\frac{3}{4}$
8	21	·38	3	3·5	5	$\frac{7}{8}$
9	24	·40	3	4·0	6	$\frac{7}{8}$
10	27	·42	$3\frac{1}{2}$	4·75	7	$\frac{7}{8}$
11	30	·44	$3\frac{1}{2}$	5·5	8	$\frac{7}{8}$
12	33	·46	4	6·25	9	$\frac{7}{8}$

NOTES.—TABLE 76 (F).

1. **Area of weld** is the product of the throat thickness and the total length of weld. The throat thickness is not to be less than 70 per cent of the leg length for a Type 1 weld. (*See* **Table 76 (A).**)

2. **Length of bracket arm** is to be measured from the plating.

3. **Thickness of brackets** at ends of vertical stiffeners on longitudinal bulkheads need not exceed ·44 inch.

TABLE 76
(SEE CONTINUATION.)

WELDING AND RIVETING.

G.

CONNECTIONS OF PRIMARY SUPPORTING MEMBERS TO

TABLE FACE AREA.		POSITION.	WELDED. TO FACE MATERIAL.				
			DOUBLE CONTINUOUS FILLET WELDS.	INTERMITTENT FILLET WELDS.			
				STAGGERED OR CHAIN.		DOUBLE FILLET WITH 6 INCH SCALLOPS.	
			Type.	S or C (All Type 1).	Distance (d) Centre to Centre.	Type.	Distance (d) Centre to Centre.
Square inches. Above.	Not exceeding.				Inches.		Inches
	5·0	For a distance each end equal to ·2 × length		S	$4\frac{1}{2}$	2	$10\frac{1}{2}$
		Remainder		S	7	2	9
5·0	10·0	For a distance each end equal to ·2 × length		C	6	1	12
		Remainder		S	6	2	9
10·0	15·0	For a distance each end equal to ·2 × length	2				
		Remainder	2*				
15·0	20·0	For a distance each end equal to ·2 × length	2				
		Remainder	2*				

* May be Type 3 clear of oil cargo tanks.

NOTES.—TABLE 76 (G).

1. **Length** for use in the above Table is the unsupported length of the member including end connections.

2. **Scallops** are not to be cut in bottom transverses, horizontal girders at ship's side and longitudinal bulkheads, or in way of end brackets.

3. On vertical webs the increased welding or riveting may be omitted at the top but at the bottom it is to extend for a distance equal to ·3 × length.

TABLE 76
(SEE CONTINUATION.)

WELDING AND RIVETING.

SHELL, DECK AND BULKHEAD AND TO FACE MATERIAL.

WELDED.					RIVETED.		
TO SHELL, DECK OR BULKHEAD.					TO FACE MATERIAL.	TO SHELL, DECK OR BULKHEAD.	
DOUBLE CONTINUOUS FILLET WELDS.	INTERMITTENT FILLET WELDS.				MAXIMUM SPACING OF RIVETS CENTRE TO CENTRE IN DIAMETERS.	NUMBER OF ROWS.	MAXIMUM SPACING OF RIVETS CENTRE TO CENTRE IN DIAMETERS.
	STAGGERED OR CHAIN.		DOUBLE FILLET WITH 6 INCH SCALLOPS.				
Type.	S or C (All Type 1).	Distance (d) Centre to Centre.	Type.	Distance (d) Centre to Centre.			
		Inches.		Inches.			
	C	$4\frac{1}{2}$	1	18	7	Double	5
	S	$4\frac{1}{2}$	2	$10\frac{1}{2}$	7	Single	5
2					4	Double	5
	C	5	1	15	6	Double	5
1					5	Double with single riveted backbar.	$4\frac{1}{2}$
2					6	Double	$4\frac{1}{2}$
1					4	Double with single riveted backbar.	4
2					5	Double	4

NOTES.—TABLE 76 (G) (*continued*).

4. In ships over 400 feet long the connection of bottom transverses to the shell is not to be less than Type 2 double continuous and that of the side transverses to shell and the vertical webs to longitudinal and transverse bulkheads is not to be less than Type 2 in the lower half; in riveted ships these connections are not to be less than double riveted angles.

5. For centre line deck and bottom girders *see* **Table 76 (H)**.

TABLE 76

(SEE CONTINUATION.)

WELDING AND RIVETING.

H.

WELDING OR RIVETING OF VARIOUS STRUCTURAL CONNECTIONS.

ITEM.			WELDED.					RIVETED.
			DOUBLE CONTINUOUS FILLET WELDS.	INTERMITTENT FILLET WELDS.				MAXIMUM SPACING OF RIVETS CENTRE TO CENTRE IN DIAMETERS.
				STAGGERED OR CHAIN.		DOUBLE FILLET WITH 6 INCH SCALLOPS.		
			Type.	S or C (All Type 1.)	Distance (d) Centre to Centre.	Type.	Distance (d) Centre to Centre.	
FRAMES & LONGITUDINALS.					Inches.		Inches.	
Side Frames to Shell	in Cargo Tanks, spacing not over 30 inches ...			S	6	2	9	6
	in Cargo Tanks, spacing over 30 inches ...			S	$5\frac{1}{2}$	2	9	$5\frac{1}{2}$
	in Deep, Oil Fuel and Peak Tanks			S	$5\frac{1}{2}$	2	9	$5\frac{1}{2}$
	in Fore Hold			S	$5\frac{1}{2}$	2	9	$5\frac{1}{2}$
	in Machinery Space, spacing not over 29 inches			S	7	3	$9\frac{1}{2}$	7
	in Machinery Space, spacing over 29 inches and up to 32 inches			S	$6\frac{1}{2}$	3	10	$6\frac{1}{2}$
	in Machinery Space, spacing over 32 inches and up to 34 inches			S	6	2	9	6
	in Machinery Space, spacing over 34 inches ...			S	$5\frac{1}{2}$	2	9	$5\frac{1}{2}$
Tween Deck Frames to Shell...				S	7	3	$9\frac{1}{2}$	7
Web Frames					*See* Table 76(G).			
Bottom Longitudinals to Shell	Where the length L does not exceed 400 ft.	For a distance either side of the bulkhead equal to ·25 × spacing of transverses	2					4
		remainder (except in the forward ·25 L)		S	6	2	9	6
	Where the length L exceeds 400 ft.	For a distance either side of bulkhead equal to ·30 × spacing of transverses	2					$3\frac{1}{2}$ with back angle
		remainder (except in the forward ·25 L)		S	6	2	9	6
	In the forward ·25 L (except at ends of span, where as above)			C	6	1	12	4 with back angle
Side Longitudinals to Shell *(cont. next page)*	Not over 15 ft. below Upper Deck at side amidships			S	6	2	9	6
	over 15 ft. and not over 25 ft. below Strength Deck at side amidships	For a distance either side of Bulkhead equal to ·25 × spacing of transverses ...	2*					$4\frac{1}{2}$
		remainder		S	6	2	9	6

* May be Type 3 clear of Oil Cargo Tanks.

For Notes see page 230.

TABLE 76
(SEE CONTINUATION.)

WELDING AND RIVETING.

H (*continued*).

WELDING OR RIVETING OF VARIOUS STRUCTURAL CONNECTIONS.

ITEM.	WELDED.					RIVETED.
	DOUBLE CONTINUOUS FILLET WELDS.	INTERMITTENT FILLET WELDS.				MAXIMUM SPACING OF RIVETS CENTRE TO CENTRE IN DIAMETERS.
		STAGGERED OR CHAIN.		DOUBLE FILLET WITH 6 INCH SCALLOP.		
	Type.	S or C (All Type 1.)	Distance (d) Centre to Centre.	Type.	Distance (d) Centre to Centre.	
			Inches		Inches	
Side Longitudinals to Shell (*continued*) — Over 25 ft. below Strength Deck at side amidships — For a distance either side of Bulkhead equal to ·25 × spacing of transverses	2					$3\frac{1}{2}$
Side Longitudinals to Shell (*continued*) — Over 25 ft. below Strength Deck at side amidships — Remainder...		S	6	2	9	6
Deck Longitudinals to Deck Plating		S	6	2	9	6
Longitudinals to stiffening bars on primary supporting members ...			*See*	**Table 76 (E).**		
Bottom Frames to Shell and floors forward		C	6	1	12	$5\frac{1}{2}$—double riveted
Floors to Centre Girder forward	1					4—double riveted
Floors and Cross Ties in fore peak		S	6	2	9	6
Floors and Cross Ties in aft peak		S	5	2	$9\frac{1}{2}$	5
PRIMARY SUPPORTING MEMBERS.						
Bottom Transverses to Shell			*See*	**Table 76 (G).**		
Side Transverses to Shell						
Deck Transverses to Deck Plating						
Web Frames to Shell						
Vertical Webs on Longitudinal Bulkheads						
Centre Line Vertical Webs on Transverse Bulkheads ...						
Stringers to Shell						
Horizontal Girders to O.T. Bulkheads						
Bottom Transverses to Longitudinal Bulkheads	1					
Deck Transverses to Longitudinal Bulkheads	2					5—double riveted
BRACKETS.						
End Brackets to all Primary Supporting Members	1					$4\frac{1}{2}$—double riveted except where the transverse is butted on the bracket; when the butt is to be treble riveted
Brackets at head of Side Frames			*See*	**Table 76 (F).**		
Side Frames to Bilge Brackets	Area of Welding to be ·75 square inches greater than required by **Table 76 (F).**					Number of rivets to be one greater than Table 76 (F). Spacing not to exceed 6 d.
End Connections of Longitudinals	1—Generally continuous (to depend on design)					
Brackets at ends of Vertical Stiffeners on Longitudinal Bulkheads...			*See*	**Table 76 (F).**		
Brackets at ends of Stiffeners on Transverse Bulkheads	To depend on end connections of Longitudinals.					
Tripping Brackets		S	6	2	9	6
Docking Brackets		S	5	2	$9\frac{1}{2}$	5
Stiffening of Primary Supporting Members		S	7	2*	$9\frac{1}{2}$	7

* May be Type 3 clear of Oil Cargo Tanks.

For Notes see page 230.

TABLE 76
(CONCLUDED.)

WELDING AND RIVETING.

H (*continued*).

WELDING OR RIVETING OF VARIOUS STRUCTURAL CONNECTIONS.

ITEM.	WELDED.					RIVETED.
	DOUBLE CONTINUOUS FILLET WELDS.	INTERMITTENT FILLET WELDS.				MAXIMUM SPACING OF RIVETS CENTRE TO CENTRE IN DIAMETERS.
		STAGGERED OR CHAIN.		DOUBLE FILLET WITH 6 INCH SCALLOPS.		
	Type.	S or C (All Type 1.)	Distance (d) Centre to Centre.	Type.	Distance (d) Centre to Centre.	
			Inches.		Inches.	
O.T. TRANSVERSE & LONGITUDINAL BULKHEADS.						
Vertical Stiffeners — spacing not exceeding 30 inches		S	6	2	9	6
Vertical Stiffeners — spacing exceeding 30 inches		S	$5\frac{1}{2}$	2	9	$5\frac{1}{2}$
Horizontal Stiffeners — Not over 15 ft. below highest point of Tank ...		S	6	2	9	6
Horizontal Stiffeners — on Longitudinal Bulkheads — over 15 ft. and not over 25 ft. — For a distance either side of Bulkhead equal to ·25 × spacing of Transverses	2					$4\frac{1}{2}$
Horizontal Stiffeners — on Longitudinal Bulkheads — over 15 ft. and not over 25 ft. — remainder		S	6	2	9	6
Horizontal Stiffeners — on Longitudinal Bulkheads — over 25 ft. — For a distance either side of Bulkhead equal to ·25 × spacing of Transverses	2					$3\frac{1}{2}$
Horizontal Stiffeners — on Longitudinal Bulkheads — over 25 ft. — remainder		S	6	2	9	6
Horizontal Stiffeners — on Transverse Bulkheads — Not over 18 ft. below highest point of Tank		S	6	2	9	6
Horizontal Stiffeners — on Transverse Bulkheads — over 18 ft..		S	5	2	9	5
Boundaries — of Longitudinal Bulkheads to Bottom or Deck ...	1					5—double riveted
Boundaries — of Transverse Bulkheads — to Shell at Bottom or Bilge ...	1					5—double riveted
Boundaries — of Transverse Bulkheads — to Shell at Sides or to Deck ...	2					5—double riveted
Boundaries — of Transverse Bulkheads — to Longitudinal Bulkheads ...	2					5—double riveted
Vertical Webs... ... ... Horizontal Girders	*See* **Table 76 (G).**					

NOTES.—TABLE 76 (H).

1. The requirements of **Section 3** of the **Rules for Electric Arc Welding in Ship Construction** are to be complied with where applicable.

2. The breadths of flanges of connecting angles are generally to be not less than four times the rivet diameter for rivets up to $\frac{7}{8}$ inch in diameter and three-and-a-half times for rivets 1 inch and above in diameter.

3. The distance from the centre of the rivet hole to the edge of the angle is to be not less than one-and-a-half rivet diameters.

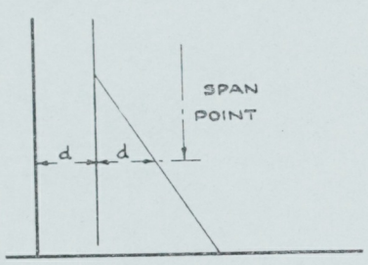
TABLE 77

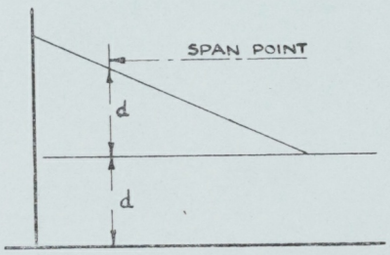
MINIMUM THICKNESS OF STRUCTURE IN CARGO TANKS AND COFFERDAMS.

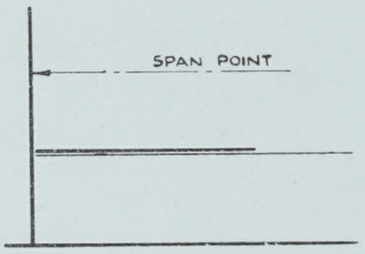
LENGTH L	MINIMUM THICKNESS.
Feet.	Inches.
250	·34
300	·36
400	·38
500	·42
600	·44

SPAN POINT.

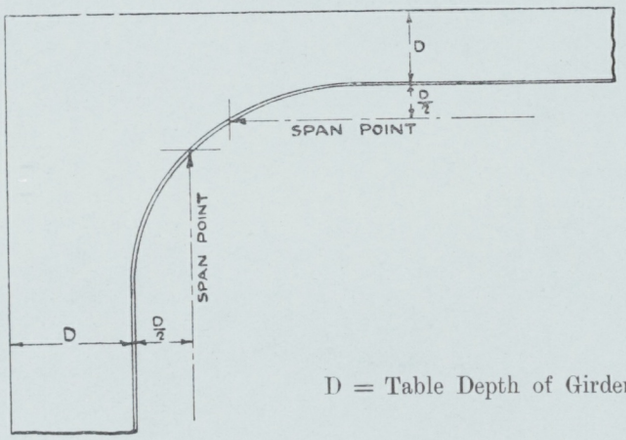
SPAN POINT FOR LONGITUDINALS, FRAMES AND STIFFENERS.



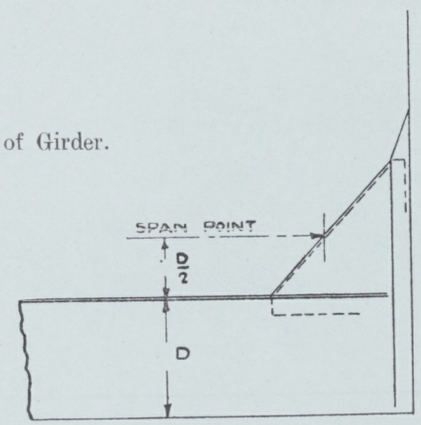


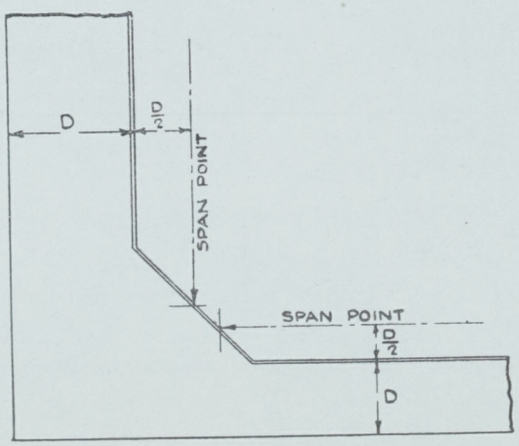


SPAN POINT FOR PRIMARY SUPPORTING MEMBERS.



D = Table Depth of Girder.





RULES FOR PUMPING AND PIPING

RULES FOR PUMPING AND PIPING.

GENERAL INDEX.

	Paragraphs.
Submission of plans	1
Bilge and ballast	2 to 77
Oil fuel and cargo oils having a flash point above 150° F.	90 to 132
Air, overflow and sounding pipes	140 to 161
Pressure pipes	170 to 187
Steam pipe ranges	200 to 205
Boiler feed water systems	210 to 224
Engine cooling water systems	230 to 236
Lubricating oil systems	240 to 246
Piping for petrol and paraffin engines	250 to 264
Pumping arrangements for ships not fitted with propelling machinery ...	270 to 273
Petroleum and other liquid cargoes having a flash point below 150° F.	280 to 302

NOTE :—*A detailed index is given for each of the larger sections.*

DETAILED INDEX.

BILGE AND BALLAST.

	Paragraphs.
Access to bilge wells	8, 9
Additional bilge suctions in single hold ship	4
After peak drainage	58, 59
After peak tank top drainage	11
Arrangement of pipes and fittings ...	41 to 57
Bilge ejector direct suction	44
Bilge fittings; position	51, 52
Bilge ejection	27, 28
Bilge pipes; flanged joints	55
„ „ provision for expansion ...	54, 56
„ „ of lead	56, 57
Bilge pump capacities	36, 37, 38
„ „ discharges	42
„ „ self-priming type	40
Bilge suction pipes:—rule sizes	32 to 35
Bilge suctions in holds	3 to 6
„ „ „ machinery spaces:— number & position	18 to 29
„ „ „ machinery spaces:— straight tail pipes ...	49
„ „ „ hold spaces:—strums	50
„ „ „ tunnel	30, 31
„ „ „ motor rooms of electrically propelled ships	25, 26, 32
„ „ led through tanks... ...	53, 54
Bilge valves of non-return type	27, 46, 47, 66
„ „ in holds	66
„ wells	6, 7
Blank flanging arrangements for deep tanks	65
Blow-down cocks or valves	68, 69
Branch bilge suctions	18 to 21, 23, 24, 30 to 35, 45
Close ceiling:—arrangements for drainage	5
Cooling water discharge to engine room bilges	29
Deep tank blank flanging arrangements	65
Direct bilge suctions	18 to 22, 26, 28, 32, 43, 44
Drainage of after peak tank top	11
„ „ fore and after peaks ...	58 to 61
„ „ machinery space	18 to 29
„ „ refrigerated spaces	12 to 17
„ „ tunnel	30, 31
Drain valves	62, 63
Electrically propelled ships:—motor room bilge drainage	25, 26, 32
Emergency bilge suctions in lieu of bilge ejections in motor ships	28
Fore and after peak drainage	58 to 61
Fore peak tank valve:—control from deck	61
General conditions for bilge and ballast drainage	2, 3
Height of valve wheels for main injection and bilge ejection valves	70
Hold and tank drainage	3 to 11
Ice navigation:—requirements for ship side valves	72
Lead pipes	56, 57
Machinery space bilge drainage	18 to 29
Machinery space bilge drainage:—ships with open floors	21
Machinery space bilge drainage:—ships with double bottom	19, 20
Machinery space bilge drainage when compartments are subdivided	26
Machinery space bilge drainage when machinery is aft	24
Machinery space bilge drainage in electrically propelled ships	25, 26, 32

	Paragraphs.
Main bilge line :—size	32, 33
Material of ship side valves	71
Mud-boxes and straight tail pipes	49
Nameplates for cocks and valves	51
Number and capacity of bilge pumps ...	36 to 38
Peak drainage	58 to 61
Plans required to be submitted	1
Pipe systems and their fittings	46 to 57
Pipes :—bilge suctions led through tanks	53, 54
„ bilge suctions of lead	56, 57
„ provision for expansion ...	54, 56
„ protection from damage by cargo or coal ...	74, 77
„ wash deck or discharge lines in way of holds ...	75
Pumps :—number and capacity	36 to 38
„ capacity table	37
„ self-priming type for bilge service ...	40
Refrigerated space drainage	12 to 17
Sanitary discharges	77
Scuppers	10, 77
Ship side valves	67 to 73
Single hold ships :—additional bilge suctions	4
Sizes of bilge suction pipes in general cargo ships	32, 34, 35
Sizes of bilge suction pipes in oil tankers	32, 33, 34
Special cases	2
Tunnel drainage	30, 31, 35
Valves :—bilge	27, 46, 47, 51, 52, 54, 66
„ bilge ejection	27, 28, 70
„ drain	62, 63
„ ship side	67 to 73
Wash deck pipes in way of holds	75
Watertight bulkhead and tunnel fittings	62 to 64

RULES FOR PUMPING AND PIPING.

PLANS.

1. The following plans are to be submitted for consideration :—

(*a*) General pumping arrangements, including air and sounding pipes. (Shipbuilder's plan.)

(*b*) Pumping arrangements at the forward and after ends of oil tankers and drainage of cofferdams and pump rooms.

(*c*) General arrangement of cargo piping in tanks and on deck of oil tankers.

(*d*) Piping arrangements for cargo oil (F.P. above 150° F.).

(*e*) Bilge, ballast and oil fuel pumping arrangements in the machinery space, including the capacities of the pumps on bilge service.

(*f*) Arrangement of oil fuel pipes and fittings at settling and service tanks.

(*g*) Arrangement of oil fuel piping in connection with oil burning installations.

(*h*) Oil fuel and cargo oil overflow systems, where these are fitted.

(*i*) Arrangement of steam pipes.

(*j*) Arrangement of boiler feed system.

(*k*) Compressed air systems.

(*l*) Oil fuel settling, service and other oil fuel tanks not forming part of the ship's structure.

(*m*) Feed water heating and filtering arrangements in installations employing superheated steam.

Plans of machinery space piping are to be diagrammatic.

BILGE AND BALLAST.

GENERAL.

2. In power-driven ships the pumping arrangements according to the division of compartments, rise of floor and other conditions are to be as detailed below.

The Committee will be prepared to give consideration to special cases or to arrangements which are fully equivalent to those required by these Rules. Consideration will also be given to the pumping arrangements of small ships and ships to be assigned notations of restricted or special services. (*See* paragraphs 270 and 273 for the pumping arrangements of non-propelled ships.)

HOLD AND TANK DRAINAGE.

3. All ships are to be provided with efficient pumping plant having the suctions and means for drainage so arranged that any water within any compartment of the ship, or any watertight section of any compartment, can be pumped out through at least one suction when the ship is on an even keel and is either upright or has a list of not more than five degrees. For this purpose wing suctions will generally be necessary, except in short, narrow compartments where one suction can provide effective drainage under the above conditions.

Bilge and ballast pipes are to be permanent pipes of cast or wrought iron, steel, copper or other approved material, except where bilge suction hoses are specifically mentioned in these Rules.

4. In ships having only one hold, and this over 110 feet in length, bilge suctions are to be fitted in suitable positions in the after half-length, also in the forward half-length of the hold.

5. Where close ceiling or continuous gusset plates are fitted over the bilges, arrangements are to be made whereby water in a hold compartment may find its way to the suction pipes.

6. Where the inner bottom plating extends to the ship's side, the bilge suctions are to be led to wells placed at the wings. If the tank top plating has inverse camber, a well is also to be fitted at the centre line.

7. Bilge wells are to be formed of steel plates and are to be of not less than six cubic feet capacity. In small compartments, steel bilge hats of reasonable capacity may be fitted.

8. Where access manholes to bilge wells are necessary, they are to be fitted as near to the suction strums as practicable.

9. Access to the bilge suction strum of a hold well should not be obtained by means of a manhole in the machinery space watertight bulkheads or tank top plating in the machinery space or tunnel if this can be avoided.

Where, however, this arrangement is necessary, the watertight manhole cover should be of hinged type and an instruction plate, in raised letters, should be affixed in a well lighted position, to the effect that this door must be kept shut, except when access is required.

10. The intactness of the machinery space bulkheads, and of tunnel plating which is required to be of watertight construction, is not to be impaired by the fitting of scuppers discharging to machinery space or tunnels from adjacent compartments which are situated below the bulkhead deck.

These scuppers may, however, be led into a strongly constructed scupper drain tank situated in the machinery space or tunnel but closed to these spaces and drained by means of a suction of appropriate size led from the main bilge line through a screw-down non-return valve fitted on the tank.

The tank air pipe is to be led to above the bulkhead deck and provision is to be made for ascertaining the level of water in the tank.

Where one tank is used for the drainage of several watertight compartments, the scupper pipes are to be provided with screw-down non-return valves.

11. Steering-gear compartments or other small enclosed spaces situated above the after peak tank are to be provided with suitable means of drainage, either by hand or power pump bilge suctions.

If, however, these compartments are adequately isolated from the adjacent 'tween decks, they may be drained by scuppers not exceeding two inches bore, discharging to the tunnel and fitted with self-closing cocks situated in well lighted and visible positions.

DRAINAGE FROM REFRIGERATED CARGO SPACES.

12. Provision is to be made for the continuous drainage of the inside of all insulated chambers and cooler trays.

13. Drains which are led from lower holds and cooler trays situated on the tank top are to be fitted with liquid sealed non-return bilge traps.

Drains from 'tween deck chambers and from cooler trays which are situated well above the tank top are also to be fitted with liquid sealed traps, but the non-return valves may be omitted if desired. (*See* par. 156 *re* Insulation of Scuppers.)

14. Where drains from separate chambers join a common main, the branch pipes are each to be provided with a liquid-sealed trap.

15. The liquid-sealed traps are to be of adequate depth and arrangements are to be made for ready access to the traps for cleaning and refilling with brine.

16. Sluices, scuppers or drain pipes which would permit drainage from compartments outside the insulated chambers into the bilges of the latter are not to be fitted.

17. Screwed plugs or other means for blanking off scuppers draining insulated chambers and cooler trays are not to be fitted.

If, however, it is specially desired by the Owners to provide means for temporarily closing these scuppers, they may be fitted with shut-off valves controlled from readily accessible positions on a deck above the load water line.

MACHINERY SPACE. NORMAL BILGE DRAINAGE.

18. The normal bilge drainage arrangements in the machinery space are to be such that any water which may enter this compartment can be pumped out through at least two bilge suctions when the ship is on an even keel and is either upright or has a list of not more than five degrees. One of these suctions is to be a branch bilge suction, *i.e.*, a suction connected to the main bilge line and the other is to be led direct from an independent power pump or steam ejector. Examples of the necessary arrangements are detailed in pars. 19–21.

19. Where the double bottom extends the full length of the machinery space and forms bilges at the wings, it will be necessary to provide one branch and one direct bilge suction at each side.

20. Where the double bottom plating extends the full length and breadth of the compartment, one branch bilge suction and one direct bilge suction are to be led to each of two bilge wells of not less than six cubic feet capacity, situated one at each side.

21. Where there is no double bottom and the rise of floor is not less than five degrees, one branch and one direct bilge suction are to be led to accessible positions as near the centre line as practicable.

If the rise of floor is less than five degrees additional bilge suctions are to be provided at the wings.

22. Where direct bilge suctions are required on both sides of the ship for normal bilge drainage, one of these suctions is to be of a size not less than required for the main bilge line, the other may be of the size required for engine room branch bilge suctions, but the smaller suction is to be fitted on the same side as the emergency bilge suction required by pars. 27 or 28.

23. Additional bilge suctions may be required for the drainage of depressions in the tank top formed by crank pits, or other recesses, by tank tops having inverse camber or by discontinuity of the double bottom.

24. In ships in which the propelling machinery is situated at the after end of the ship, it will generally be necessary for bilge suctions to be fitted in the forward wings as well as the after end of the machinery space, but each case will be dealt with according to the size and structural arrangements of the compartment.

25. In ships propelled by electrical machinery, special means are to be provided to prevent the accumulation of bilge water under the main propulsion generators and motors.

26. Where the machinery space mentioned above is divided by watertight bulkheads to separate the boiler room(s) or auxiliary engine room(s) from the main engine room, the number and position of the main bilge line suctions in the boiler room(s) and auxiliary engine room(s) are to be the same as for cargo holds.

In addition to the main bilge line suctions an independent power pump direct bilge suction, or a steam bilge ejector suction, is to be fitted in each compartment. Similar provision is to be made in separate motor rooms of electrically propelled ships.

The normal drainage arrangements in the main engine room are to be as detailed in pars. 18–25.

MACHINERY SPACE.

EMERGENCY BILGE DRAINAGE.

27. In steamers, the main circulating water pump(s) are to be fitted with emergency bilge suction(s), *i.e.*, "bilge ejection(s)," which are to be additional to the normal bilge suctions detailed above. These suctions, which are to have a diameter of at least two thirds that of the sea inlet, are to be led to a suitable low level in the machinery space and are to be fitted with screw-down non-return valves having the spindles extended so that the handwheels are not less than 18 inches above the bottom platform.

28. In motor ships, emergency bilge drainage is to be provided by a bilge ejection led from the main cooling water suction line and of the same size as that line.

Alternatively, the emergency bilge drainage may be provided by a direct bilge suction led from the largest available power pump and is to be of the same size as the suction branch of the pump.

This emergency suction, which corresponds to the bilge ejection in steamers, is additional to the normal direct bilge suctions required by par. 18, and is to comply with the requirements of par. 27 as regards location and valve arrangements.

The valve name plate is to be marked "For emergency use only."

Cooling Water Discharge to Bilges.

29. Where a considerable quantity of cooling water is discharged to the machinery space bilges, special arrangements are to be made to deal with this water, in addition to the ordinary bilge pumping arrangements.

TUNNEL DRAINAGE.

30. The tunnel well is to be drained by a suction from the main bilge line.

31. Where the tank top in the tunnel slopes down from aft to forward, a bilge suction is to be provided at the forward end of the tunnel, in addition to the tunnel well suction required by the preceding paragraph.

SIZES OF BILGE SUCTION PIPES.

32. The diameters of bilge suction pipes are to be not less than required by the following formulæ, to the nearest quarter inch :—

Main Bilge Line.

$$d_m = \sqrt{\frac{L\ (B + D)}{2500}} + 1 \qquad (1)$$

In no case is the diameter of the main bilge line to be less than required for any branch bilge suction.

Branch Bilge Suctions to Cargo and Machinery Spaces.

$$d_b = \sqrt{\frac{C\ (B + D)}{1500}} + 1 \qquad (2)$$

where d_m = Internal diameter of main bilge line in inches.

where d_b = Internal diameter of branch bilge suction in inches.

L = Rule length of ship, in feet.

B = Rule breadth of ship, in feet.

D = Moulded depth to bulkhead deck, in feet.

C = Length of compartment, in feet.

No bilge suction pipe is, however, to be less than two inches bore.

Direct Bilge Suctions, other than Emergency Suctions.

One of the direct bilge suctions in the main engine room and the direct bilge suctions in large separate boiler rooms, motor rooms of electrically propelled ships and auxiliary engine rooms are to be of a diameter not less than required for the main bilge line.

The other direct bilge suction in the main engine room may, as stated in par. 22, be of the diameter required for the engine room branch bilge suctions.

Where the separate machinery spaces are of small dimensions, the sizes of the direct bilge suctions to these spaces will be specially considered.

Emergency Bilge Suctions.

For sizes of, see pars. 27 and 28.

33. In oil tankers and similar ships where the engine room pumps do not deal with bilge drainage outside the machinery space, the diameter of the main bilge line may be less than required by Formula (1) provided the cross-sectional area is not less than twice that required for the branch bilge suctions in the machinery space.

34. The area of each branch pipe connecting the bilge main to a bilge distribution chest is to be not less than the sum of the areas required by the Rules for the two largest branch bilge suction pipes connected to that chest, but need not be greater than that required for the main bilge line.

35. The bilge suction pipe to the tunnel well is to be not less than $2\frac{1}{2}$ inches bore, except in ships not exceeding 200 feet in length, in which case it may be two inches bore.

BILGE AND GENERAL SERVICE PUMPS.

Number and Capacity of Pumps.

36. Not less than two power operated bilge pumping units are to be provided in the machinery space, one of which may be worked from the main engines. The other unit is to be independently driven.

Each of these units is to be connected to the main bilge line and is to be capable of giving a speed of water through the Rule size of bilge line of not less than 400 feet per minute under ordinary working conditions, but where one unit is of slightly less than this capacity, the deficiency may be made good by an excess capacity of the other unit.

37. TABLE OF CAPACITIES.

Bore of Bilge Pipe in inches	Capacity of each Pumping Unit in Tons/Hr.	Bore of Bilge Pipe in inches	Capacity of each Pumping Unit in Tons/Hr.
2	15	$5\frac{1}{4}$	103
$2\frac{1}{4}$	19	$5\frac{1}{2}$	113
$2\frac{1}{2}$	23	$5\frac{3}{4}$	124
$2\frac{3}{4}$	28	6	135
3	34	$6\frac{1}{4}$	146
$3\frac{1}{4}$	40	$6\frac{1}{2}$	158
$3\frac{1}{2}$	46	$6\frac{3}{4}$	171
$3\frac{3}{4}$	53	7	183
4	60	$7\frac{1}{4}$	197
$4\frac{1}{4}$	68	$7\frac{1}{2}$	210
$4\frac{1}{2}$	76	$7\frac{3}{4}$	224
$4\frac{3}{4}$	84	8	239
5	93	$8\frac{1}{4}$	254

38. Each unit may consist of one or more pumps connected to the main bilge line, provided their combined capacity is adequate.

39. The steam bilge ejector mentioned in pars. 18 and 44 is not accepted as a substitute for the independent bilge pump required by par. 36.

Self-Priming Pumps.

40. All power pumps which are essential for bilge services are to be of self-priming type, unless an approved central priming system is provided for these pumps. Details of this system are to be submitted.

Cooling water pumps having bilge ejection connections need not be of self-priming type.

Pump Connections.

41. The connections at the bilge pumps are to be such that one unit may continue in operation when the other unit is being opened up for overhaul.

42. Pumps required for essential services are not to be connected to a common suction or discharge chest or pipe unless the arrangements are such that the working of any of the pumps so connected is unaffected by the other pumps being in operation at the same time.

Direct Bilge Suctions.

43. The direct bilge suctions required for normal bilge drainage in the machinery space(s) are to be led to independent power pump(s), and the arrangements are to be such that these direct suctions can be used independently of the main bilge line suctions.

Ejector Suctions.

44. Steam bilge ejector suction(s) of similar size to the power pump direct bilge suctions mentioned above may be substituted for the latter, provided the capacity of the ejector be not less than required by par. 37 and there be adequate means of replenishing the boiler feed water expended as steam by the ejector(s).

If it is desired to employ compressed air or water in lieu of steam for the ejector, details are to be submitted.

Main Bilge Line Suctions.

45. Suctions from the main bilge line are to be arranged to draw water from any hold or machinery compartment of the ship, excepting small spaces such as those mentioned in pars. 59 and 60, where manual pump suctions are accepted, and are to be of not less size than required by Formula (2) of par. 32.

For special arrangements for oil tankers *see* pars. 291 to 296.

Pipe Systems and their Fittings.

46. The arrangement of valves, cocks and their connections is to be such as to prevent the possibility of one watertight compartment being placed in communication with another, or of dry cargo spaces, machinery spaces or other dry compartments being placed in communication with the sea or with tanks.

To effect this requirement, the bilge connections to any pump having also suctions from the sea and from tanks should be made either by means of non-return valves or cocks which cannot permit communication between the bilges and the sea or compartments in use as tanks.

47. Screw-down non-return valves are to be provided in the following fittings:—

(1) Bilge valve distribution chests;
(2) Bilge suction hose connections, whether fitted direct to the pump or on the main bilge line;
(3) Direct bilge suctions and bilge pump connections to main bilge line.

48. Bilge pipes which are required for draining cargo or machinery spaces are to be entirely distinct from sea inlet pipes or from pipes which may be used for filling or emptying spaces where water or oil is carried. This does not, however, exclude a bilge ejection connection, a connecting pipe from a pump to its suction valve chest, or a deep tank suction pipe suitably connected through a change-over device to either a bilge, ballast or oil line.

49. Suctions for normal bilge drainage in machinery spaces and tunnels are to be led from easily accessible mud-boxes fitted with straight tail pipes to the bilges and having covers secured in such a manner as to permit of their being expeditiously opened or closed. Strum boxes are not to be fitted to the lower ends of these tail pipes.

50. The open ends of bilge suctions in holds and other compartments outside machinery spaces and tunnels, are to be enclosed in strum boxes having perforations not more than $\frac{3}{8}$-inch diameter, whose combined area is not less than twice that required for the suction pipe. The boxes are to be so constructed that they can be cleared without breaking any joint of the suction pipe.

The distance between the foot of all bilge tail pipes and the bottom of the bilge or well is to be adequate to allow a full flow of water and to facilitate cleaning.

51. All cocks and valves in connection with bilge, ballast and fresh water suction pipes are to be fitted with legible nameplates, and, unless otherwise specifically mentioned in the Rules, are to be fitted in places where they are at all times readily accessible.

52. Bilge cocks, valves and mud-boxes are to be fitted at, or above, the machinery space and tunnel platforms.

Where it is not practicable to avoid the fittings being situated at the starting platform or in passageways, they may be situated just below the platform, provided readily removable traps or covers are provided and nameplates indicate the presence of these fittings.

If relief valves are fitted to pumps having sea connections, these valves are to be fitted in readily visible positions above the platform.

53. Bilge suction pipes are not to be carried through double bottom tanks if it is possible to avoid doing so.

Bilge pipes which pass through these tanks are to be of substantial strength and are to be tested, after fitting, to the same pressure as the tanks through which they pass.

54. In way of deep water ballast, oil fuel or cargo oil tanks bilge pipes should preferably be led through pipe tunnels, but where this is not done, the pipes are to be of steel of heavy gauge and fitted in one length, if practicable, or with welded joints.

Expansion bends, not glands, are to be fitted to these pipes within the tanks, and the open ends of the bilge suction pipes in the holds are to be fitted with non-return valves of the special type approved for use in holds (*see* par. 66).

The pipes are to be tested, after fitting, to a pressure not less than the maximum head to which the tanks can be subjected.

55. Bilge, ballast and cooling water suction and discharge pipes are to be made in readily removable lengths with flanged joints, except as mentioned in the preceding paragraph, and are to be efficiently secured in position to prevent chafing or lateral movement.

Long or heavy lengths of pipes are to be supported by bearers so that no undue load is carried by the flanged connections of the pumps or fittings to which they are attached.

Where lack of space prevents the use of normal circular flanges, details of the alternative methods of joining the pipes are to be submitted.

56. Suitable provision for expansion is to be made in each range of pipes and where the connections at bulkheads and other structural parts of the ship are made with lead bends, the radii of the bends and the distance between the axes of the straight parts of the pipe are each to be not less than three diameters and the length of the bend is to be at least eight diameters of the pipe.

57. Bilge suction pipes of lead are not permissible in engine rooms, boiler rooms or other compartments in which oil fuel storage tanks, cargo oil tanks or oil fuel appliances are situated. Nor are they to be used within coal bunkers or attached to bunker bulkheads or oil tanks.

FORE AND AFTER PEAK DRAINAGE.

58. Where the peaks are used as tanks, a separate power pump suction is to be led to each tank, except in the case of small tanks used for the carriage of domestic fresh water, when hand pumps may be used.

59. Where the peaks are not used as tanks and main bilge line suctions are not fitted, drainage of both peaks may be effected by hand pump suctions, provided the suction lift be well within the capacity of the pumps and in no case exceeds 24 feet.

60. Provision is to be made for the drainage of the chain locker and the watertight flat above the fore peak tank by hand or power pump suction. (For drainage of the flat above the after peak tank *see* par. 11.)

61. Where a suction pipe is led from the engine room to the fore peak, either through a hold space or through a tank intended to carry oil fuel, it is to be provided with a screw-down valve capable of being operated from an accessible position above the bulkhead deck, the chest being secured to the collision bulkhead inside the fore peak. An indicator is to be provided to show whether the valve is open or shut.

WATERTIGHT BULKHEAD AND TUNNEL FITTINGS.

62. No drain valve or cock is to be fitted to the collision bulkhead.

63. Drain valves or cocks are not to be fitted to other watertight bulkheads, if alternative means of drainage are practicable.

Where fitted, the valves and cocks are to be at all times readily accessible and are to be capable of being shut off from positions above the bulkhead deck. Indicators are to be provided to show whether the drains are open or shut. (For drainage of stern compartments *see* par. 11.)

64. Valve chests, cocks, pipes or other fittings attached direct to the plating of tanks, and to bulkheads, flats or tunnels which are required to be of watertight construction, are to be secured by means of studs screwed through the plating or by tap bolts and not by bolts passing through clearance holes.

Alternatively, the studs or the bulkhead piece may be welded to the plating.

Deep Tanks.

65. In the case of deep tanks which may be used for either water ballast or dry cargo, provision is to be made for blank flanging the water ballast filling and suction pipes when the tank is being used for the carriage of dry cargo and for blank flanging the bilge suction pipes when the tank is being used for the carriage of water ballast.

Change-over devices may be used for this purpose. (*See* also par. 109 for arrangements when oil fuel or cargo oil is carried in deep tanks.)

Hold Bilge Valves.

66. Where non-return valves are fitted to the open ends of bilge suction pipes in cargo holds in order to decrease the risk of flooding, they are to be of an approved type which does not offer undue obstruction to the flow of water.

Ship Side Valves (other than those on Scuppers and Sanitary Discharges).

67. All sea inlet and overboard discharge pipes are to be fitted with valves or cocks fitted direct to the shell plating or to the plating of fabricated steel water boxes attached to the shell plating. These fittings are to be secured by bolts tapped into the plating and fitted with countersunk heads or by studs screwed into heavy steel pads fitted to the plating. The stud holes are not to penetrate the plating.

Distance pieces of short rigid construction, and made of approved material as required by par. 71, may be fitted between the valves and shell plating. Distance pieces of steel may be welded to the shell plating. Details of the welded connections and of fabricated steel water boxes are to be submitted.

68. All suction and discharge valves and cocks direct on the shell plating of the ship are to be fitted with spigots passing through the plating, but the spigots on the valves or cocks may be omitted if these fittings are attached to pads or distance pieces which themselves form spigots in way of the shell plating.

Blow-down cocks or valves are also to be fitted with a protection ring through which the spigot is to pass, the ring being on the outside of the shell plating.

69. Blow-down cocks or valves on the ship's side are to be fitted in accessible positions above the level of the working platform and are to be arranged so that it can be readily seen whether they are open or shut. Cock handles are not to be capable of being removed unless the cocks are shut, and if valves are fitted, the wheels are to be fixed to the spindles.

70. Sea inlet cocks and valves are in all cases to be fitted in easily accessible positions and, as far as practicable, are to be readily visible.

The valve spindles are to extend above the lower platform, and the hand wheels of the main injection and bilge ejection valves are to be situated not less than 18 inches above this platform.

71. Where valves or cocks are over three inches bore, they are to be of steel or an approved grade of cast iron or other approved material; this requirement applies equally to inlet chests, distance pieces, and other sea connections.

All these fittings, if made of steel, are to be suitably protected against wastage.

72. In ships having a notation for ice strengthening, the sea inlet and overboard discharge valves which are situated below the maximum load line are to be provided with connections from the boiler, or compressed air receivers for clearing purposes. Low pressure steam or air is to be used for this purpose.

73. The scantlings of valves and valve stools fitted with steam or compressed air clearing connections are to be suitable for the maximum pressure to which the valves and stools may be subjected.

Miscellaneous Requirements.

74. All pipes situated in cargo spaces, coal bunkers, chain lockers or other positions where they are liable to mechanical damage are to be efficiently protected. (*See* also pars. 77 and 161.)

75. Wash deck pipes and discharge pipes from the pumps to domestic water tanks are not to be led through cargo holds if, as is generally the case, it is practicable to avoid doing so. Any proposed departure from this requirement is to be submitted.

76. As far as practicable, pipe lines, including exhaust pipes from oil engines, are not to be led in the vicinity of switchboards or other electrical appliances in positions where drip or escape of liquid, gas or steam from joints or fittings may cause damage to the electrical installation.

Where it is not practicable to comply with these requirements, drip trays or shields are to be provided as found necessary.

Short sounding pipes to tanks should not terminate near electrical appliances. (*See* also par. 152.)

SCUPPERS AND SANITARY DISCHARGES.

(Extracts from Section 25 of Rules for Steel Ships.)

77. **Section 25, clauses 3 to 6.—Scuppers.**—(*a*) Scuppers sufficient in number and size to provide effective drainage are to be fitted in all decks.

(*b*) When the weather deck stringer angle is cut in way of scuppers compensation is to be provided.

(*c*) Scupper pipes which drain spaces below the freeboard deck are to be led to the bilges, or may be led overboard provided the spaces drained are above the load waterline and the scuppers are fitted with screw-down non-return valves capable of being operated from a position always accessible and above the freeboard deck. Means are to be provided for showing whether the valves are open or closed.

(*d*) Scuppers draining spaces in intact superstructures or in superstructures having the openings in the end bulkheads closed by strong hinged steel doors may be led to the bilges or may be led overboard and fitted if considered necessary wth screw-down non-return valves as required by (*c*) above.

(*e*) Scuppers draining spaces in short superstructures having the openings in the end bulkheads closed by appliances as described in Section 23, clause 1 (*d*), are to be led overboard, with the exception of the scuppers above the machinery space which may be led to the bilges where the lower ends of the pipes are to be visible and readily accessible.

(*f*) Scuppers which drain overboard from spaces referred to in (*d*) and (*e*) above and which are not required to have storm valves with positive means of control are to be fitted with non-return valves of automatic type.

(*g*) Scuppers draining spaces in long superstructures having the openings in the end bulkheads closed by appliances as described in Section 23, clause 1 (*d*) are, within the range of the machinery space, to be led to the bilges where the lower ends of the pipes are to be visible and readily accessible.

Where additional scuppers are required to ensure effective drainage of the spaces clear of the machinery space these scuppers are to be led to the hold bilges and fitted with screw-down valves at the freeboard deck, the valves being controlled from a position which is accessible at all times above the freeboard or superstructure deck. Means are to be provided for showing whether the valves are open or closed.

(*h*) Plans showing the arrangement of scuppers for draining refrigerated cargo compartments are to be submitted for consideration.

Sanitary Discharges.—(*a*) Sanitary discharges from spaces below the freeboard deck are to be provided with efficient and accessible means of preventing water from passing inboard.

Each discharge is to have a screw-down automatic non-return valve operated from an accessible position above the freeboard deck. Means are to be provided for showing whether the valve is opened or closed.

Alternatively, two automatic non-return valves, without positive means of closing, may be fitted provided the upper valve is in a position which is always accessible for examination.

(*b*) Discharges from spaces within enclosed superstructures are each to be fitted with automatic non-return valves, but arrangements similar to those described in (*a*) above may be required.

Materials for Valves and Pipes.—Castings enclosing non-return valves are to be of substantial construction. These castings, also the elbow pieces where no valves are required, are to be of approved material other than ordinary cast iron. The length of pipe attached to the valve or elbow piece is to be of galvanised steel of standard steam pipe quality.

Protection of Pipes and Valves.—In all cargo spaces or coal bunkers, scupper pipes, discharges and screw-down valves and their controls are to be well protected; in coal bunkers the protection is to be of steel.

DETAILED INDEX.

OIL FUEL AND CARGO OILS HAVING A FLASH POINT ABOVE 150° F.

	Paragraphs.
Alternative carriage of oil fuel and water ballast	108, 109
Blank flanging arrangements for deep tanks	109
Boilers:—insulation	115
„ distance from oil storage tanks	115, 116
„ smoke box doors and uptakes ...	117
„ funnel dampers	118
Burning installation	91 to 96
Capacity of each oil burning unit	91
Cargo oil, separation from oil fuel	129
Control of outlet valves on deep tanks and service tanks	103
Control of oil fuel and cargo oil pumps ...	122
Drain cocks or valves on deep tanks and service tanks	107, 113
Drainage at oil tank bulkheads	110, 132
Drip trays	128, 132
Escape valves on oil fuel pumps and heaters	96
Fresh water piping	111
Funnel dampers	118
General requirements	90
Heating coils or pipes	119 to 121
Insulation of boilers	115
Materials of pipes	... 98 to 100, 120
Nameplates for cocks and valves	104
Number of oil burning units required	91
Number of filters required in gravity oil burning installation	93
Observation tank	119
Oil burning installations:—	
pressure systems	91, 92, 96, 98, 99
number and capacity of units	91
gravity system	93
steam injection type	94
starting-up unit	95
escape valves	96
control of unit pressure pumps	122
Oil fuel drainage	128, 130 to 132
Oil fuel and water ballast:—alternative carriage	108, 109
Oil fuel pumps:—escape valves	96
„ „ control	122
Oil pipes:—hot oil fuel discharge to burners ...	98
„ „ short lengths at burners	99
„ „ suction and transfer	100
„ „ flexible pipes at burners	99
„ „ materials	98 to 100
Oil fuel service and settling tanks:—Scantlings	112
Oil valves:—isolation valves in engine and boiler space ...	102
„ „ on deep tanks and service tanks ...	103
„ „ position in machinery spaces	102 to 105
„ „ on filling pipes to deep tanks ...	106
„ „ design of covers	104
Prohibition of use of wood in boiler rooms, etc.	127
Precautions against fire	123 to 128
Refrigerated cargo chambers, oil drainage	130, 131
Transfer pumps:—control	
„ „ stand-by pump	97
Ventilation	114
Water drainage from settling tanks	113
Water service pipes in boiler room	126
Wood fittings:—prohibition of use in boiler rooms, etc.	127

OIL FUEL AND CARGO OILS HAVING A FLASH POINT ABOVE 150° F.

General.

90. In addition to the special requirements detailed below, the preceding requirements relating to bilge and ballast are to be complied with in so far as they are applicable to the drainage of tanks, oil bilges and cofferdams.

Oil Fuel Pumps and Oil Burning Appliances.

91. In every ship where steam for the main propelling engines or for auxiliary machinery which is required for essential services, is generated by burning oil fuel under pressure, there are to be not less than two oil burning units, each unit comprising a pressure pump, a suction filter, a discharge filter and a heater.

In two unit installations, each unit is to be capable of supplying fuel for generating all the steam required for essential services.

In installations of three or more units, the capacities and arrangements of the units are to be such that all the steam required for essential services can be maintained with any one unit out of action.

92. Unit pressure pumps for the oil burning system are to be entirely separate from the feed, bilge or ballast systems.

93. In systems where oil is fed to the burners by gravity, Duplex filters are to be fitted in the supply pipe line to the burners, arranged so that one filter can be opened up when the other is in use.

94. If oil fuel is sprayed by steam, means are to be provided to carry or make up the fresh water used for this purpose.

95. A starting-up oil fuel unit, including an auxiliary heater and hand pump, or other suitable starting-up device, which does not require power from shore, is to be provided.

96. All pumps used in connection with oil fuel are to be provided with effective escape valves which are to be in close circuit, *i.e.*, discharging back to the suction side of the pumps.

Escape valves are also to be fitted on the oil side of the heaters, discharging to the pump suction line, to the tray under the unit, or to other approved position, and are to be adjusted to operate at a pressure of 50 lb. per square inch above that of the pump escape valve.

97. Where a power driven transfer pump is necessary for pumping up the settling tanks, a stand-by pump is to be provided and connected ready for use, or alternatively, emergency connections may be made to one of the unit pumps or to another suitable power driven pump.

Oil Pipes and Fittings.

98. Pipes conveying heated oil under pressure are to be of seamless steel having flanged couplings and placed in sight above the platform in well-lighted parts of the stokehold or engine room.

The flanges are to be machined and the jointing material, which is to be impervious to oil heated to 250° F., is to be the thinnest possible, so that the flanges are practically metal to metal. The scantlings of the pipes and their flanges are to be suitable for at least 200 lb. per square inch working pressure, or the pressure to which the relief valves are adjusted, whichever is the greater.

The pipes, heaters and their fittings are to be tested after jointing to not less than 400 lb. per square inch or to double the working pressure, whichever is the greater.

The thickness of the oil fuel pressure pipes is to be determined from the formula contained in par. 182.

99. The short joining lengths of pipes to the burners from the control valves on the boiler front may have cone unions of specially robust construction.

Flexible pipes of approved material and design may be used for the burner pipes provided spare lengths, complete with couplings, be carried on board.

A quick closing master valve is to be fitted on the hot oil supply to each boiler manifold.

100. Transfer, suction and other low pressure oil pipes and all pipes passing through oil storage tanks are to be made of cast or wrought iron or steel, having flanged joints suitable for a working pressure of not less than 100 lb. per square inch. The flanges are to be machined and the jointing material is to be impervious to oil. Oil pipes within the engine and boiler spaces are to be fitted where they can be readily inspected and repaired, and after jointing they are to be tested to 50 lb. per square inch, or twice the maximum working pressure, whichever is the greater.

Valves and Cocks.

101. The valves, cocks and their pipe connections are to be so arranged that oil cannot be admitted into tanks which are not structurally suitable for the carriage of oil or into tanks which can be used for the carriage of fresh water intended for boiler feed or for drinking.

102. All oil suction pipes are to be fitted with valves or cocks at or near the bulkheads where they enter the engine and boiler space, unless the pipes are already provided with readily controlled shut-off valves outside this space.

103. The outlet valves or cocks at all oil storage, settling and daily service tanks, other than double bottom tanks, are to be secured to the tanks and so geared that they may be shut off from positions which will always be accessible in the event of fire taking place in the compartment in which they are situated. Indicators are to be provided at the valves and on deck to show whether the valves or cocks are open or shut.

In the case of fore peak tanks, these valves are to be fitted on the tank side of the bulkhead, and in the case of after peak tanks, in the tunnel or inside the tanks.

104. All valves and cocks in the machinery space forming part of the oil fuel installation are to be capable of being controlled from above the engine and boiler room platforms, and oil fuel valves are to be so constructed as to prevent the possibility of any cover being slacked back or loosened when operating the valves. The cocks and valves are to be fitted with legible nameplates.

105. Valves or cocks are to be interposed between the pumps and the suction and discharge pipes, in order that any pump may be shut off for opening up and overhauling.

106. Where the filling pipes to deep oil tanks are not connected to the tanks near the top, they are to be provided with non-return valves at the tanks or with valves or cocks fitted and controlled as in the case of the outlet valves or cocks on these tanks.

107. Open drains for removing the water from oil tanks are to be fitted with cocks or valves of self-closing type and suitable provision is to be made for collecting the oily discharge.

Alternative Carriage of Oil Fuel and Water Ballast.

108. Where it is intended to carry oil fuel and water ballast in the same compartments alternatively, the valves or cocks connecting the suction pipes of these compartments with the ballast pump and those connecting them with the oil fuel transfer pump are to be so arranged that the oil may be pumped from any one compartment by the oil fuel pump at the same time as the ballast pump is being used on any other compartment.

Where settling or service tanks are fitted having each a capacity sufficient to permit of 12 hours normal service without replenishment, the above requirement may be dispensed with.

Deep Tanks for the Alternative Carriage of Oil, Water Ballast or Dry Cargo.

109. In the case of deep tanks which can be used for the carriage of oil fuel, cargo oil, water ballast or dry cargo, provision is to be made for blank flanging the oil and water ballast filling and suction pipes, also the steam heating coils if retained in place, when the tank is used for dry cargo and for blank flanging the bilge suction pipes when the tanks are used for oil or water ballast.

If the deep tanks are connected to an overflow system, the arrangements are to be such that liquid or vapour from other tanks cannot enter the deep tanks when dry cargo is carried in them.

Oily Bilge Drainage and Sediment Suctions.

110. Provision is to be made for the drainage of oil gutterways, oil wells and cofferdams. (*See* also par. 132.)

Fresh Water Piping.

111. Pipes in connection with compartments used for storing boiler feed water are to be separate and distinct from any pipes which may be used for

oil or oily water, and are not to be led through tanks which contain oil, nor are oil pipes to be led through boiler feed water tanks.

Similar precautions are necessary when the connections are such that fresh water carried in other tanks can be used as reserve feed water.

Service, Settling and other Oil Fuel Tanks.

112. In general, the minimum thickness of the plating of these tanks, when they do not form part of the structure of the ship, is to be $\frac{1}{4}$ inch, but in the case of very small tanks, the minimum thickness may be $\frac{1}{8}$ inch. Adequate stiffening of the plating is to be provided where necessary.

Water Drainage from Settling Tanks.

113. Settling tanks are to be provided with means for draining water from the bottom of the tanks.

If settling tanks are not provided, the oil fuel bunkers or daily service tanks are to be fitted with water drains. (*See* also par. 107.)

Ventilation.

114. The spaces in which the oil fuel burning appliances, and the oil fuel settling and service tanks are fitted, are to be well ventilated and easy of access.

Boiler Insulation and Air Circulation in Boiler Room.

115. The boilers are to be suitably lagged. The clearance spaces between the boilers and tops of the double bottom tanks and between the boilers and the sides of the storage tanks in which oil fuel or cargo oil is carried, are to be adequate for the free circulation of air necessary to keep the temperature of the stored oil well below its flash point.

116. Where water tube boilers are installed, there should be a space of at least two feet six inches between the tank top and the underside of the pans forming the bottom of the combustion spaces.

117. Smoke-box doors are to be shielded and well fitting, and the uptake joints made air tight.

Funnel Dampers.

118. Dampers which are capable of completely closing the gas passages are not to be fitted to inner funnels of ships equipped for burning oil fuel only. In ships burning oil or coal alternatively, dampers may be retained if they are provided with a suitable device whereby they may be securely locked in the fully open position.

Steam Heating Arrangements.

119. Where steam is used for heating oil fuel, cargo oil or lubricating oil, either in bunkers, tanks, heaters or separators, the exhaust drains are to discharge the condensate into an observation tank in a well lighted and accessible position where it can be readily seen whether or not it is free from oil. (*See* also par. 297.)

120. The steam heating pipes in contact with oil are to be of cast or wrought iron or steel and are to be tested, after being fitted on board, to twice the maximum pressure to which they can be subjected.

121. The working pressure of the steam heating pipes is to be determined from the formulæ in par. 182.

Control of Pumps.

122. The power supply to the oil fuel transfer and unit pressure pumps and to the cargo oil pumps is to be capable of being stopped from a position which will always be accessible in the event of fire taking place in the compartment in which they are situated, as well as from the compartment itself.

Precautions against Fire.

123. Settling and daily service oil fuel tanks and oil fuel filters are not to be situated immediately above boilers or other highly heated surfaces.

124. Oil fuel pressure pipes are to be led, wherever practicable, remote from heated surfaces and electrical appliances, but where this is impracticable, the pipes are to have a minimum number of joints and are to be led in well-lighted and readily visible positions.

125. Short sounding pipes to oil fuel tanks are not to be situated adjacent to boilers or to electric generators or motors. (For alternative sounding arrangements *see* par. 150.)

126. Water service pipes and hoses are to be fitted so that the floor plates and tank top or shell plating in way of boilers, oil fuel apparatus or deep storage tanks in the engine and boiler spaces can at any time be flushed with sea water.

127. So far as is practicable the use of wood is to be avoided in the engine rooms, boiler rooms and tunnels of ships burning oil fuel.

128. Drip trays are to be fitted at the furnace mouths to intercept oil escaping from the burners and under all other oil fuel appliances which require to be opened up frequently for cleaning or adjustment. The arrangements are to be such that a burner cannot be withdrawn unless the oil fuel supply to that burner is shut off.

Separation of Cargo Oils from Oil Fuel.

129. Pipes conveying vegetable oils or similar cargo oils are not to be led through oil fuel tanks, nor are oil fuel pipes to be led through tanks containing these cargo oils. (*See* also concluding requirement of par. 132.)

Oil Drainage in way of Refrigerated Cargo Chambers.

130. The insulation of all oil storage tank tops is to have an air space of two inches provided between the under side of the insulation and the tank top plating and the supporting battens are to be arranged athwartship to permit of free drainage to the bilges. As an alternative to the air space, approved inodorous material not less than half inch in thickness may be laid on the tank top plating.

131. A cofferdam is to be fitted separating deep tanks intended for the carriage of oil from refrigerated compartments unless the tank bulkhead is wholly welded including its boundary connections, in which case the cofferdam may be omitted and an air space of not less than two inches arranged between the insulation and the bulkhead plating to provide for free drainage from the latter into the oil gutterway and thence to the bilges.

Provision is to be made for ventilating the cofferdam or air space, the vents being led to the open air and their outlets being fitted with a wire gauze diaphragm which can easily be removed for renewal.

Bulkhead Oil Drainage and Provision of Cofferdams. (Extracts from Sections 20 and 21 of Rules for Steel Ships.)

132. **Section 20, clause 12.**

(*a*) Compartments carrying oil are to be separated by cofferdams from those carrying fresh water; oil fuel compartments are to be similarly separated from those carrying vegetable oil.

Cofferdams are to be suitably ventilated. (*See* par. 110 *re* drainage.)

(*b*) Sparring or lining is to be fitted on the bulkheads in holds to prevent leakage of oil coming into contact with the cargo.

Gutterways are to be arranged at the foot of these bulkheads to ensure that leakage shall have free drainage to the wells or limbers.

Gutterways are also to be fitted in boiler spaces.

(*c*) Where a bulkhead, including its boundary connections, is wholly welded, the requirements of (*b*) above may be dispensed with, except that a gutterway is to be fitted in the boiler room.

(*d*) Ceiling on the inner bottom, if fitted, is to be laid on battens not less than half an inch in thickness. Battens are to be laid so as to permit the drainage of oil to the bilges or wells.

(*e*) Drip trays or gutterways, with suitable draining arrangements, are to be provided for all tanks which do not form part of the ship's structure, at pumps, valves and elsewhere where there is a possibility of leakage. Drip trays are also to be fitted under oiltight decks, except if these are completely welded when the drip trays need only be fitted over the boilers.

(*f*) If cargo or coal is carried in a compartment adjacent to an oil fuel settling tank which may be heated, the compartment side of the bulkhead or deck is to be insulated.

Section 21, clause 2.

(*c*) Deep or peak tanks carrying vegetable or similar oils are to be separated from those carrying oil fuel or fresh water, by a cofferdam.

DETAILED INDEX.

AIR, OVERFLOW AND SOUNDING PIPES.

	Paragraphs.
Access to sounding pipes	151, 152
Air pipes in refrigerated spaces	156
Alternative carriage of oil and water ballast, arrangement of overflow	147
Areas of air and overflow pipes	144
Area of openings in wire gauze diaphragms	144
Closing appliances: precautions against excessive pressures	143
Curvature in sounding pipes	151
Depth gauges	150
Elbow sounding pipes	159
Fittings on short sounding pipes ...	152, 154
Gauge glasses on settling or service tanks ...	153
Height of air pipes	141, 161
Height of sounding pipes	151, 152
Material and thickness of air and overflow pipes	148
Material and thickness of sounding pipes ...	157
Overflow systems	145
Overflow tanks	146
Position of air pipes	140, 141, 142
Position of sounding pipes	149, 151, 152
Self-closing cocks or valves on gauge glasses ...	153
Short sounding pipes in machinery spaces and tunnels	152
Short sounding pipes not to be used as air pipes	160
Sizes of sounding pipes	155
Sounding pipes in refrigerated spaces ...	154, 155, 156
Striking plates under sounding pipes	158
Test cocks not permitted	153
Tank sounding devices	150

AIR, OVERFLOW AND SOUNDING PIPES.

Air and Overflow Pipes.

140. Air pipes are to be fitted at the outboard corners of tanks at the opposite end of the tank to that at which the filling pipes are placed and/or at the highest part of the tank.

Where the tank top is of unusual or irregular profile, special consideration will be given to the number and position of the air pipes.

Where a single air pipe is fitted it is not to be used as a filling pipe.

Name plates are to be affixed to the upper ends of all air pipes.

141. Air pipes to double bottom tanks, deep tanks extending to the shell plating or tanks which can be run up from the sea are to be led to above the bulkhead deck.

Air pipes to oil fuel and cargo oil tanks, cofferdams and all tanks which can be pumped up are to be led to the open. (For height of air pipes above deck, *see* par. 161 for extract from **Section 24**, clause 5 (*b*) of the **Rules for Steel Ships**.)

142. The open ends of air pipes to oil fuel and cargo oil tanks are to be situated where no danger will be incurred from issuing oil or vapour when the tank is being filled and each opening is to be furnished with a wire gauze diaphragm of incorrodible material which can be readily removed for cleaning or renewal.

143. Arrangements are to be made to prevent excessive pressure coming on the tanks in the event of positive closing appliances being fitted to the upper ends of those air pipes which also serve as overflow pipes. Details of these precautionary arrangements are to be submitted.

144. In the case of all tanks which can be pumped up, either by the ship's pumps or by shore pumps through a filling main, the total cross sectional area of the air pipes to each tank or of the overflow pipes where an overflow system is provided, is to be not less than 50 per cent greater than the area of the effective filling pipes.

In wire gauze diaphragms at air pipe openings, the area of the clear opening is to be not less than the cross sectional area required for the pipe.

Air pipes are to be not less than two inches bore.

145. The arrangement of the overflow system is to be such that in the event of any one of the tanks being bilged, tanks situated in other watertight compartments of the ship cannot be flooded from the sea through the overflow main.

Air and overflow pipes are to be arranged to be self-draining under normal conditions of trim.

146. If an overflow system is provided for the oil fuel storage or cargo oil tanks, the discharge from this system is to be led to an overflow tank.

Overflows from settling or daily service tanks are to be led back to the storage tanks or to an overflow tank, and an alarm device or a sight glass in the overflow pipe is to be provided to indicate when the tanks are overflowing.

Alternatively, the alarm device may be arranged to give warning when the oil reaches a predetermined level in the settling or daily service tanks.

Overflow tanks which are the only means of relieving the storage tanks of undue pressure are to be of sufficient capacity to take ten minutes' flow at the normal rate of loading.

147. Where overflows from tanks which are used for the alternative carriage of oil and water ballast are connected to an overflow system, arrangements are to be made to prevent water ballast overflowing into tanks containing oil. (*See* also par. 109.)

148. Air and overflow pipes are to be of steel or wrought iron and should have a minimum thickness of ·19 inch. Pipes slightly less in thickness may be accepted, provided they be suitably coated to prevent

corrosion. Where not in contact with oil fuel or cargo oil, suitable protection may be provided by galvanising the pipes on completion.

Where flanged connections are employed, heavy flanges with closely spaced bolts are to be fitted.

Sounding Pipes.

149. Provision is to be made for sounding all tanks, and the bilges of those compartments which are not at all times readily accessible.

The soundings are to be taken as near the suction pipes as practicable.

150. Tank sounding devices will be accepted in lieu of sounding pipes, provided details of the devices have been submitted for consideration and accepted by the Committee. These devices are to be tested, after fitting on board, to the satisfaction of the Surveyors.

151. Sounding pipes, including those for the double bottom tanks below the machinery spaces, should be led to positions above the bulkhead deck which are at all times accessible.

These pipes should be as straight as practicable, and if curved to suit the structure of the ship, the curvature must be sufficiently easy to permit the ready passage of the sounding rod or chain.

Name plates are to be affixed to the upper ends of all sounding pipes.

152. In machinery spaces and tunnels where it is not always practicable to extend the sounding pipes as mentioned in the preceding paragraph, short sounding pipes extending to readily accessible positions above the platform may be fitted, provided those to oil fuel and lubricating oil tanks are not situated adjacent to boilers or electric generators or motors, and are fitted with cocks having parallel plugs with permanently attached handles so loaded that, on being released, they automatically close the cocks.

Short sounding pipes to tanks other than oil tanks are to be fitted with shut-off cocks or with screw caps attached to the pipes by chains.

153. Neither round gauge glasses nor test cocks are to be used for ascertaining the level of oil in storage, settling or service tanks, but suitably protected gauges of approved design, having flat glasses of substantial thickness and self-closing cocks or valves, may be fitted on shallow settling or service tanks.

154. Sounding pipes to oil compartments are not to terminate within refrigerated cargo chambers or in the fan and battery rooms for these chambers, nor are these pipes to terminate in enclosed spaces from which access is provided to refrigerated cargo chambers or their fan and battery rooms, if it be practicable to avoid doing so.

Where these sounding pipes do terminate in such spaces they are to be fitted with self-closing cocks having parallel plugs.

155. Sounding pipes are to be not less than $1\frac{1}{4}$ inches bore. Where sounding pipes pass through refrigerated spaces, or the insulation thereof, in which the temperatures contemplated are lower than 33° F., they are to be not less than $2\frac{1}{2}$ inches bore.

156. All pipes, including scupper pipes, air pipes and sounding pipes, which pass through refrigerated chambers are to be well insulated.

Where such pipes pass through steel work which forms part of a boundary of a space, in which the temperature contemplated is below 33° F., the pipes are to be insulated from the plating, and in the case of pipes adjacent to the shell plating, metallic contact between the pipes and the shell plating or frames is to be arranged as far as practicable.

157. Sounding pipes are to be of steel or wrought iron having a minimum thickness of ·17 inch.

Pipes slightly less in thickness may be accepted, provided they be suitably coated to prevent corrosion. Where not in contact with oil fuel or cargo oil, suitable protection may be provided by galvanising the pipes on completion.

Where flanged connections are employed, heavy flanges with closely spaced bolts are to be fitted.

158. Striking plates of adequate thickness and size are to be fitted under open ended sounding pipes.

When slotted sounding pipes having closed ends are employed, the closing plugs are to be of substantial construction.

159. Elbow sounding pipes are not to be used for deep tanks unless the elbows are situated within closed cofferdams or within tanks containing similar liquids.

They may, however, be fitted to other tanks and may be used for sounding bilges, provided it is not

practicable to lead them direct to the tanks or compartments.

The elbows are to be of heavy construction and adequately supported.

160. The internal lengths of short sounding pipes are not to be arranged for the escape of air or vapour from the tanks into the compartments in which they are situated.

HEIGHT OF AIR PIPES ABOVE DECK.

(Extract from Section 24 of the Rules for Steel Ships.)

161. Section 24, clause 5.—(*b*) The height of air pipes, from upper surface of deck to opening, on decks exposed to the weather, is to be as follows:—

On the uppermost continuous deck where the draught is the maximum permitted for the dimensions of the ship, with the depth D measured to that deck ... ... 36 inches

On raised quarter decks ... ... 30 inches

On superstructure decks other than raised quarter decks, but including those extending for the full length of the ship ... 18 inches

(*c*) Openings of air and sounding pipes are to be provided with satisfactory arrangements to prevent the free entry of water.

(*d*) Striking plates of sufficient thickness, or their equivalent, are to be fitted under all sounding pipes.

(*e*) In all cargo spaces or coal bunkers, air and sounding pipes are to be well protected and in coal bunkers the protection is to be of steel.

DETAILED INDEX.

PRESSURE PIPES.

	Paragraphs.
Annealing of copper pipes	171, 181
Attachment of flanges to steel pipes	183
Bending of copper pipes	176
Branches welded to steel pipes	184
Compressed air pipes	182
Copper pipes:—allowance for bending	176
„ annealing	171
„ brazed pipes	175
„ electro-deposition method of manufacture not accepted	170
„ formulæ for working pressure and thickness ...	175
„ maximum dimensions	173
„ maximum temperature	174
„ radius of curvature of bends	176
„ seamless pipes	172, 175
„ steam pipes	173, 174, 175
„ thickness	175
„ working pressures	175
Feed pipes:—working pressures	175, 172
Flanges on steel pipes	183
Heating coils in oil tanks	180, 185
Hydraulic test pressures	185
Iron pipes	187
Oil fuel pressure pipes	178, 182, 185
Reduced pressure pipe lines	186
Reinforcement required in way of welded branches	184
Steam pipes:—working pressures ...	175, 182
Steel pipes:—butt welded pipes	180
„ compressed air pipes	182
„ formulæ for working pressure and thickness	182
„ oil fuel pressure pipes	182
„ lap welded pipes	179, 182
„ limiting temperature for mild steel pipes...	177
„ seamless	178, 182
„ stress relieving	181
Welded pipe flanges	183
Welded pipe branches	184
Working pressures:—formulæ	175, 182
„ stresses	182

PRESSURE PIPES.

Copper Pipes.

170. Pipes made from the electro-deposition of copper on a mandril are not to be used.

171. Pipes are to be carefully annealed on completion and prior to testing by hydraulic pressure.

172. All pipes which are subject to a working pressure over 75 lb. per square inch are to be seamless.

173. Steam pipes intended for a working pressure over 180 lb. per square inch are not to be of copper when the internal diameter exceeds 5 inches.

174. Copper pipes are not to be used for a temperature above 425° F.

175. The working pressure to be allowed on copper pipes is to be determined by the following formula :—

$$WP = \frac{(t-3) \times F}{d}$$

Where **WP** is the working pressure in lb. per square inch, which, in the case of feed pipes, is to be taken as 1·25 times the boiler pressure,

d is the internal diameter in inches,

t is the thickness in 100ths of an inch,

F for seamless pipes = 60,
for brazed pipes = 45.

176. Where copper pipes are bent, they are to be made thicker by 1 S.W.G. (approximately ·02 inch) than required by the preceding paragraph to provide for thinning at the bend.

In no case is the radius of curvature at the centre line of the pipe to be less than twice the external diameter of the pipe.

Steel Pipes.

177. Steam and other pipes for temperatures not exceeding 850° F. may be made of mild steel complying with the requirements of **Section 16** of the **Rules for Quality and Testing of Materials.**

Where it is proposed to use special heat resisting materials for any temperature exceeding 800° F., full particulars are to be submitted.

178. Steam pipes for pressures above 250 lb. per square inch or temperatures above 425° F., feed pipes and oil pressure pipes conveying heated oil are to be seamless.

179. Pipes, other than those mentioned in the preceding paragraph, may be lap welded, provided the welded seams are formed by an approved mechanical process.

180. Pipes having butt welded longitudinal seams are not to be used for oil fuel systems, for heating coils in oil tanks, or for pressures exceeding 50 lb. per square inch.

181. On completion of any work on steel pipes for pressures in excess of 150 lb. per square inch or temperatures in excess of 500° F., which involves heating, whether for welding the joint or bending the pipe, or for any other purpose, the pipes are to be stress relieved at about 600°/650° C.

The requirements of this paragraph do not apply to the welded attachments of the flanges detailed in Figs. 4, 5 and 8 of par. 183.

182. The working pressure to be allowed on steel pipes is to be determined from the following formula :—

$$\text{W.P.} = \frac{2\ S}{D}\ (t - C) \text{ or } t = \frac{\text{W.P.} \times D}{2\ S} + C$$

Where W.P. = Working pressure in lb. per square inch.

In the case of feed pipes, W.P. is generally to be taken as 1·25 times the boiler pressure, or boiler pressure + 100 lb. per square inch, whichever is the greater, but in no case is to be less than the maximum pressure which can be developed in the feed line.

Where t = Thickness of pipe, in inches.

„ D = External diameter of pipe, in inches.

„ C = 0·06 for compressed air and oil fuel pressure pipes, seamless.
0·08 for other pipes, seamless, cold finished.
0·10 for other pipes, seamless, hot finished.
0·12 for lap welded pipes.

„ S = for seamless mild steel pipes—
7,500 lb. per square inch up to 650° F.
7,000 lb. per square inch at 700° F.
6,460 lb. per square inch at 750° F.
5,850 lb. per square inch at 800° F.
5,080 lb. per square inch at 850° F.
for lap welded pipes 5,000 lb. per square inch.
Intermediate values by interpolation.

Attachment of Flanges to Steel Pipes.

183. (*a*) Flanges may be attached to pipes by means of screwing and expanding or welding.

(*b*) Firms proposing to attach flanges or branches to pipes by means of welding should, in the first instance, in the presence of the Surveyors, weld specimens which are to be cut up for the purpose of ascertaining that the weld metal is sound and the penetration satisfactory.

Periodically check tests similar to the foregoing are to be carried out at the Surveyors' discretion.

(*c*) Where flanges are welded-on by the oxy-acetylene or metal arc processes, the welding is to be carried out by means of approved filler rods, or electrodes.

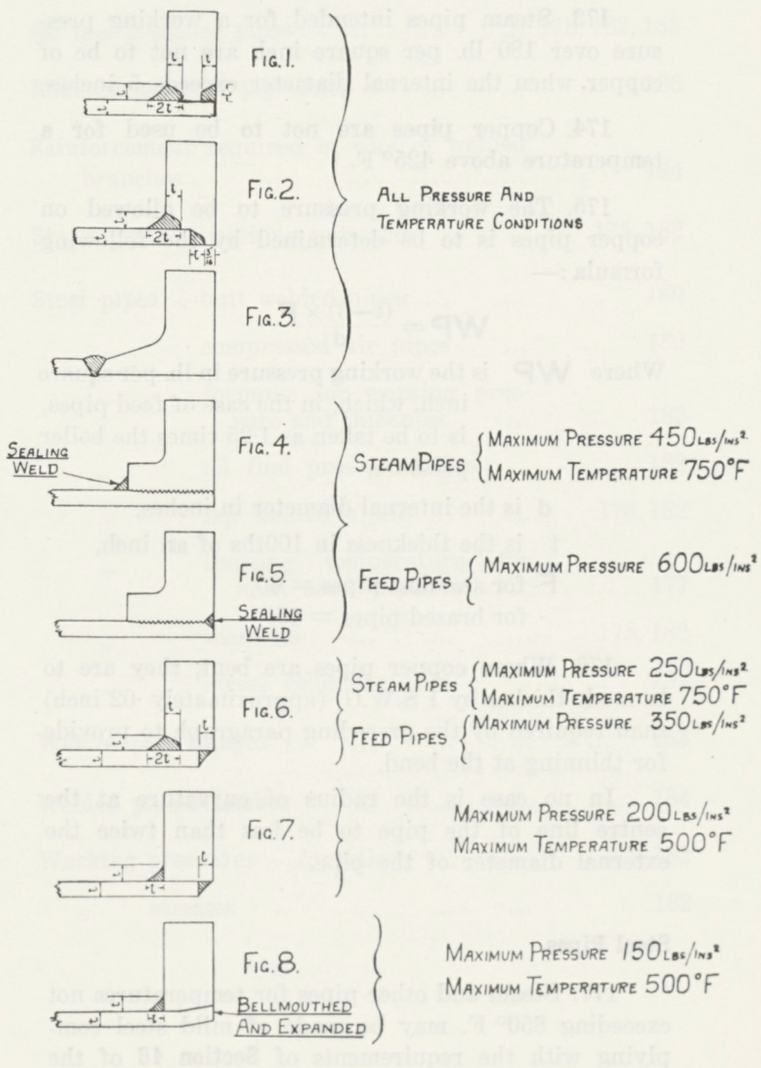
(*d*) Where flanges are secured by screwing, the pipe and flange are to be screwed with a vanishing thread and the diameter of the screwed portion of the pipe over the thread must not be appreciably less than the outside diameter of the unscrewed pipe. After the flange has been screwed hard home the pipe is to be expanded into the flange and may be provided with a sealing weld. *See* Figs. 4 and 5.

The vanishing thread on a pipe is to be not less than three pitches in length, and the diameter at the root of the thread is to increase uniformly from the standard root diameter to the diameter at the top of the thread. This may be produced by suitably grinding the dies, and the flange should be tapered out to the same formation.

(*e*) Flanges which employ welding wholly or partly as a method of attachment may be attached by any of the methods shewn below.

Alternative methods of attachment will be accepted, provided details are submitted, the pressure and temperature conditions being stated.

TYPICAL ACCEPTABLE METHODS OF SECURING FLANGES TO STEEL PIPES.



NOTE:- THE PROPORTIONS INDICATED FOR THE WELDS ARE MINIMA ONLY

184. Where branches are attached by means of welding to steam or other pressure pipes, suitable reinforcement is to be provided in way of the branch or the thicknesses of both branch and pipe are to be increased to maintain the strength of the pipe.

These requirements also apply to fabricated branch pieces.

GENERAL REQUIREMENTS.

Hydraulic Test Pressures.

185. Pipes, valves or fittings intended for working pressures in excess of 150 lb. per square inch are to be subjected, on completion, to an hydraulic test of not less than twice the working pressures defined in pars. 175 and 182.

In the case of oil fuel pipes and heating coils in oil tanks, hydraulic tests are to be carried out on the completed systems, as required by pars. 98 and 100 for oil pipes, and par. 120 for heating coils.

Reduced Pressure Lines.

186. Pipe lines which are situated on the low pressure side of reducing valves and which are not designed to withstand the full pressure at the source of supply are to be fitted with pressure gauges and with relief valves having sufficient discharge capacity to protect the piping against excessive pressure.

Cast Iron Pipes.

187. Where it is desired to use pressure pipes of cast iron, details are to be submitted.

STEAM PIPE RANGES.

Provision for Expansion.

200. In all steam pipe ranges provision is to be made for expansion and contraction to take place without unduly straining the pipes.

Where corrugated pipes are used, particulars are to be submitted.

Drainage.

201. The slope of the pipes and the number and position of the drain cocks or valves are to be such that water can be efficiently drained from any portion of the steam pipe range when the ship is in normal trim and is either upright or has a list up to five degrees.

Arrangements are to be made for ready access to the drain cocks or valves.

Pipes in way of Holds.

202. Pipes conveying steam are not to be led through spaces which may be used for cargo, except with the approval of the Committee.

If these pipes are led through shaft tunnels, pipe tunnels in way of cargo holds or through duct keels, they are to be efficiently secured and insulated.

Materials.

203. Valves and fittings subjected to steam pressures exceeding 150 lb. per square inch or to steam temperatures exceeding 425° F., and main engine stop valve chests, are to be of steel or other approved material.

204. For the working pressures and test pressure of steam pipes of copper or steel, see pars. 175, 182 and 185.

STEAM FOR FIRE EXTINGUISHING IN CARGO HOLDS.

205. Where steam is used for fire extinguishing in cargo holds, provision is to be made to prevent damage to cargo by leakage of steam or by drip.

Details of the proposed precautionary measures are to be submitted.

DETAILED INDEX.

BOILER FEED WATER SYSTEMS.

	Paragraphs.
Automatic control of independent main feed pumps	215
Capacity of feed pumps	211, 212
Connections to independent feed pumps ...	218, 221
Feed pipes:—materials, scantlings and test pressures	170 to 187
„ systems:—number required ..	210
„ water filters	222, 223
„ water:—isolation from oil or oily water	220
General service pump	221
Harbour feed pump or injector	216
Omission of sea suction to independent feed pump	219
Pumping unit—capacity	211, 212
„ „ definition	212
„ „ independent pumps ...	213 to 216, 218, 221
„ „ isolation of pumps for overhaul	217
„ „ main engine pumps ...	213, 214
„ „ number of units required	211
Reserve feed water	220
Twin screw ships:—number of main engine feed pumps	214

BOILER FEED WATER SYSTEMS.

Feed Pumps.

210. Two separate means of feed are to be provided for all main, auxiliary and donkey boilers which are required for essential services, with the exception of boilers heated exclusively by exhaust gases, where one means of feed will be accepted.

211. Not less than two feed pumping units are to be provided, each of which is to be capable of supplying the requisite amount of feed water to the boilers under full load conditions.

212. A feed pumping unit is to consist of one or more power pumps suitably connected and is to have a total capacity not less than that required in the preceding paragraph.

213. The pump(s) of one main boiler feed unit may be worked from the main engines, but those of the other unit are to be independently driven.

214. In twin screw steamers in which there is only one independent feed pump, each main engine is to be fitted with a feed pump of adequate capacity. Where both of the feed pumping units are independently driven, each unit is to be connected to deal with the condensate from both engines or from either engine.

215. Independent feed pumps required for feeding the main boilers are to be fitted with automatic regulators for controlling their output.

216. Where main engine-driven feed pumps are fitted and there is only one independent feed pump, a harbour feed pump or an injector is to be fitted to provide the second means of feed to the boilers which are in use when the main engines are not working.

217. Feed pumps are to be provided with valves or cocks so that either pumping unit may continue in operation when the pumps of the other unit are being opened up for overhaul or adjustment.

218. One of the independent feed pumps is to be provided with an emergency suction to the sea, except in the cases mentioned in par. 219.

Suctions are also to be provided from this pump to the hotwell or condenser, unless suitable stand-by connections have already been provided for this purpose.

219. In the case of water tube boilers or high pressure cylindrical boilers, the sea suction to a feed pump may be omitted if large reserve feed tanks are provided and an evaporator of adequate capacity is fitted.

220. All ships fitted with boilers are to be provided with storage space for reserve feed water, the structural and piping arrangements being such that this water cannot be contaminated by oil or oily water.

221. An auxiliary independent feed pump may be used for general service, provided it is not connected to tanks containing oil fuel or cargo oil or to tanks, cofferdams and bilges containing oily water.

The valves on the suction pipes from the hotwell or condenser and the feed drain tank or filter are to be of non-return type.

222. Where superheated steam es used in main or auxiliary engines of reciprocating type, filters are to be fitted to provide for the continuous filtration of the boiler feed water.

223. Where a direct contact heater is supplied with exhaust steam from engines of reciprocating type, the feed water from the heater is to be led through the filters required by the preceding paragraph or through additional filters arranged to provide for continuous filtration.

In lieu of the additional filters, an efficient oil separator may be fitted in the steam supply to the heater.

224. For materials, working pressure and test pressure of feed pipes, *see* pars. 170 to 185.

MISCELLANEOUS SERVICES.

ENGINE COOLING WATER SYSTEMS.

Main Supply.

230. Provision is to be made for an adequate supply of cooling water to the main propelling machinery and essential auxiliary engines, also to the lubricating oil and fresh water coolers where these coolers are fitted. The cooling water pump(s) may be worked from the engines or be driven independently.

Alternative Supply.

231. Provision is also to be made for a separate emergency supply of cooling water from a suitable pump.

Sea Inlets.

232. Not less than two independent sea inlets are to be provided for the pumps supplying the salt water cooling system, one for the main pump and one for the stand-by pump.

These inlets are to be low inlets and one of them may be the ballast pump or general service pump sea inlet.

Stand-by Fresh Water Pump.

233. Where fresh water cooling is employed, a stand-by fresh water pump need not be fitted if there be suitable emergency connections from a salt water system.

Cooling Water Supply to Auxiliaries.

234. Where a group of auxiliaries receive their cooling water from a common system instead of each auxiliary having its own cooling water pump, a stand-by cooling water pump is to be provided for this auxiliary system. This pump may be a suitable general service pump.

Strainers.

235. Where sea water is used for the direct cooling of the main engines and essential auxiliary engines, the cooling water suction pipes are to be provided with strainers which can be cleaned without interruption to the cooling water supply.

Relief Valves.

236. Cooling water pumps worked from the main engines are to be provided with relief valves on the pump discharge.

LUBRICATING OIL SYSTEMS.

Pumps.

240. In ships of unrestricted class in which the lubricating oil for the main engines is circulated under pressure and the total power exceeds 400 I.H.P. in the case of steam reciprocating engines and 350 S.H.P. in the case of turbines and internal combustion engines, not less than two lubricating oil pumps are to be fitted and connected ready for immediate use, each pump being of sufficient capacity for normal power.

Similar provision is to be made where separate lubricating oil systems are employed for the operation of reverse reduction gears and oil operated couplings.

Emergency Supply for Main Turbines and Main Turbo-Generators.

241. A suitable emergency supply of lubricating oil is to be provided. This may be effected by arranging for an automatic gravity supply of lubricating oil sufficient to maintain adequate lubrication for not less than 3 minutes, and in the case of turbo-generators until the unloaded turbine comes to rest from its maximum rated running speed.

An alarm device is also to be arranged to give audible warning in the event of the failure of, or an appreciable reduction in, the supply of lubricating oil from the pump.

Strainers.

242. Where the lubricating oil for the main propelling engines and for the generator engines in electrically propelled ships is circulated under pressure, provision is to be made for efficiently straining the lubricating oil.

243. The strainers or filters are to be capable of being cleaned without stopping the oil supply to the engine.

244. Where strainers are fitted on the discharge side of the lubricating oil pump, a relief valve in close circuit is to be fitted between the pump and the strainer.

Drip Trays.

245. In the ships built of wood, easily drained metal or metal-lined trays are to be fitted to prevent saturation of the woodwork by leakage from the engine and its filters.

Lubrication of Bearings.

246. For details of the requirements relating to the lubrication of bearings of electric generators and motors, *see* Section 5, clause 11, of the Rules for Electric Propelling Machinery, also Section 2, clause 14, and Section 12, clause 9, of the Rules for Electrical Equipment.

PIPING FOR PETROL AND PARAFFIN ENGINES.

General.

250. The arrangements are to comply, in general, with the requirements for steamers and ships propelled by heavy oil engines, in so far as these requirements are applicable.

The special requirements detailed in the following paragraphs are also to be complied with.

Fuel Tank Filling.

251. Filling stations are to be in the open, having permanent filling pipes to all tanks which are situated within enclosed spaces.

Fuel Tank Air Pipes.

252. All tanks are to be fitted with air pipes led to the open in positions where no danger will be incurred by escaping gas or liquid.

The upper ends of the air pipes are to be fitted with wire gauze diaphragms of incorrodible material, which are to be readily detachable for cleaning.

Fuel Tank Sounding.

253. Wherever practicable, the arrangements for sounding the tanks are to be such that the quantity of fuel in the tanks can be readily ascertained from positions in the vicinity of the filling station.

254. Gauge glasses are not to be fitted to storage or service tanks containing either petrol or paraffin.

255. Sounding pipes are to be led to the open deck and are not to terminate in an enclosed space. Striking plates are to be fitted under all sounding pipes, and the sounding rods are to be of non-ferrous material.

Ventilation.

256. The engine room and the compartments in which the fuel tanks are situated are to be efficiently ventilated.

Drainage.

257. All separate fuel tanks are to be provided with metal trays to prevent any possible leakage from the tanks into the bilges. Similar provision is to be made for dealing with leakage from filters and carburettors.

258. Drip trays are to be arranged so that they can be readily drained by a hand pump or into a portable container through a drain cock.

259. In wooden ships drip trays are to be fitted under the main and auxiliary engines and lubricating oil filters and pumps to prevent saturation of the woodwork by lubricating oil.

Large trays under engines may, however, be replaced by small trays fitted under all parts of the engine from which leakage of lubricating oil is possible.

Suitable arrangements are to be made for collecting the drainage from the crank case when renewing the engine lubricating oil.

260. Trays under petrol tanks, carburettors or vaporisers and filters are to be covered with wire gauze.

Piping.

261. All petrol or paraffin fuel pipes are to be of annealed seamless copper with flexible bends, and the joints are to be conical, metal to metal.

Where alternative arrangements are desired, details are to be submitted.

The pipes are to be led in positions where they are protected from mechanical injury and, as far as practicable, they are to be exposed to view throughout their length.

262. The carburettor or vaporiser and the filters are to be provided with shut-off valves or cocks to permit of their being opened up for overhaul without emptying the connecting pipes.

263. Carburettors and vaporisers are to be so designed that when the engine is stopped the fuel supply is automatically shut off.

If an overflow is provided in the carburettor or vaporiser, a gauze-covered tray, as required by the preceding paragraphs, is to be fitted to prevent the fuel from flowing into the bilges.

Strong metallic gauze diaphragms are to be fitted either between the carburettor or vaporiser and the cylinders, and at the air inlets.

264. The exhaust pipes and silencer are to be efficiently water cooled or lagged to prevent damage by heat, and if the exhaust is led overboard near the load water line, means are to be provided to prevent water from being syphoned back to the engine. Special arrangements are to be made for drainage if the exhausts are cooled by water spray.

PUMPING ARRANGEMENTS FOR SHIPS NOT FITTED WITH PROPELLING MACHINERY.

Hand Pumps.

270. Where auxiliary power is not provided, hand pumps are to be fitted in number and position as may be required for the efficient drainage of the ship.

The pumps are to be capable of being worked from the upper deck or from positions above the load water line which are at all times readily accessible.

The suction lift is not to exceed 24 feet, and is to be well within the capacity of the pump.

271. The sizes of the hand pumps are not to be less than given in the following table:

Tonnage under Upper Deck	Hand Pumps	
	Diameter of barrel of bucket pump.	Bore of Suction pipe of bucket pumps and semi-rotary pumps.
	inches	inches
Not exceeding 500 tons ...	4	2
Above 500 tons but not exceeding 1,000 tons ...	$4\frac{1}{2}$	$2\frac{1}{4}$
Above 1,000 tons but not exceeding 2,000 tons ...	5	$2\frac{1}{2}$
Above 2,000 tons	$5\frac{1}{2}$	$2\frac{3}{4}$

Where the ship is closely subdivided into small watertight compartments 2 inch bore suctions will be accepted.

Power Pumps.

272. In ships in which auxiliary power is available on board, power pump suctions are to be provided for dealing with the drainage of tanks and of the bilges of the principal compartments.

The pumping arrangements are to be as required for self-propelled ships in so far as these requirements are applicable, duly modified to suit the size and service of the ship.

Details of the pumping arrangements are to be submitted for special consideration.

Fire Extinguishing.

273. Wherever practicable, a power pump or hand pump is to be fitted having a suction from the sea and a discharge to deck for fire extinguishing purposes.

Where oil fuel is used for the generation of power, details of the fire extinguishing appliances are to be submitted.

DETAILED INDEX.

PETROLEUM AND OTHER LIQUID CARGOES HAVING A FLASH POINT BELOW 150° F.

		Paragraphs.
Arrangement of Tanker	situation of machinery	280
Cargo Pipe Lines ...	isolation from spaces outside cargo tanks	295
„ „ „ ...	provision for expansion	285
Cargo Pumps	control	283
„ „	escape valves ...	284
„ „	exclusive use for cargo tanks	283
„ „	motive power ...	300, 301
„ „	driven by shafting ...	301
Cargo Pump Rooms ...	access and ventilation	287
„ „ „ ...	bilge drainage ...	286
„ „ „ ...	fire extinguishing ...	302
„ „ „ ...	isolation from machinery spaces ...	282
Cargo Pump Rooms ...	steam drains	299
Cofferdams	drainage	293
„	isolation from cargo oil system ...	294
Gas freeing arrangements		289
Heating coils in cargo tanks		297
Isolation of cargo oil system from other pipe systems		283, 295
„ „ „	bunkers ...	296
„ „ „	machinery spaces ...	282
Observation drain tank		297
Pumps at forward end of ship		292
Steaming out connections		298
Ullage arrangements		288
Vapour pipes to cargo oil tanks		290

PETROLEUM AND OTHER LIQUID CARGOES HAVING A FLASH POINT BELOW 150° F.

General.

280. The following requirements are based on the assumption that the ships are of normal tanker type having the main propelling machinery aft.

Departures from normal type will require special consideration.

Cargo Oil System.

281. A complete system of piping and pumps is to be fitted for dealing with the cargo oil.

282. Cargo pump rooms are to be enclosed by oil-tight bulkheads and are to have no direct communication with machinery spaces.

283. Pumps for the purpose of filling or emptying the cargo oil tanks are to be used exclusively for this purpose, except as provided for by par. 286. They are not to have any connections to compartments outside the range of cargo oil tanks.

Cargo oil pumps are to be capable of being controlled from outside the pump rooms, as well as at the pumps.

284. The pumps are to be provided with effective escape valves which are to be in close circuit, *i.e.*, discharging to the suction side of the pumps.

285. Expansion joints or bends are to be provided where necessary in the cargo pipe lines.

286. Provision is to be made for the bilge drainage of the cargo pump rooms by pump or bilge ejector suctions. The cargo pumps or cargo stripping pumps may be used for this purpose, provided the bilge suctions are fitted with screw-down non-return valves and, in addition, an isolating valve or cock be fitted on the pump connection to the bilge chest. The pump room bilges of small tankers may be drained by means of a hand pump having a 2 in. bore suction.

Pump room suctions are not to enter machinery spaces.

287. Pump rooms are to be provided with ready means of access and adequate ventilation.

288. Ullage plugs or sighting ports are to be provided at each tank to enable the amount of ullage to be ascertained.

289. Provision is to be made for the gas freeing of the cargo oil tanks when the cargo has been discharged and for the ventilation and gas freeing of all compartments adjacent to cargo oil tanks.

290. Vapour pipes are to be fitted to the hatches of the cargo oil tanks and connected through shut-off cocks or valves to a vapour line led up the mast to a position above the navigation lights. The outlets from these vapour mains are to be provided with readily renewable wire gauze or safety heads of approved type. If alternative means of dealing with the vapour are desired, details are to be submitted.

BILGE, BALLAST, OIL FUEL AND OTHER PIPING NOT WITHIN THE CARGO OIL SYSTEM.

291. The pumping arrangements in the machinery space and at the forward end of the ship are to comply with the requirements for general cargo ships in so far as they are applicable and with the special requirements detailed below.

292. A separate power pump is to be fitted in a suitable compartment forward of the cargo tanks to deal with bilge drainage, water ballast and oil fuel pumping at the fore end of the ship.

In small tankers, a forward power pump may be dispensed with, provided suitable alternative arrangements are made, details of which are to be submitted.

293. Where the after deep cofferdam can be filled with water ballast, a ballast pump in the main engine room may be used for emptying the cofferdam, provided the suction be led direct to the pump and not to an engine room pipe system.

294. Cofferdams are not to have any connections to the cargo oil tanks or cargo oil lines.

Where intended to be dry compartments only, hand pumps or bilge ejector suctions are to be provided.

Cofferdams are to be provided with sounding pipes and with air pipes led to the open. These air pipes are to be fitted with wire gauze diaphragms at their outlets.

295. Bilge, ballast, oil fuel and other piping connected to the pumps at the ends of the ships are not to pass through the cargo oil tanks or have any connection to these tanks.

Cargo oil pipes are not to pass through ballast or oil fuel tanks or through compartments which are external to the cargo oil system.

296. The oil fuel bunkering system is to be entirely separate from the cargo oil system.

Steam and Exhaust Piping.

297. Where heating coils are provided in the cargo oil tanks they are to be made and fitted under the usual conditions of survey and testing. (*See* pars. 177 to 204.)

An observation tank is to be provided for the heating coil drains and is to be situated in a well-ventilated and well-lighted part of the machinery space remote from the boilers.

298. Steaming out and fire extinguishing connections for cargo oil tanks or cargo oil pipe lines are to be fitted with valves of non-return type and the main supply to these connections is to be fitted with a master valve placed in a readily accessible position clear of the tanks.

299. In the cargo pump rooms, drain pipes from steam or exhaust pipes or from the steam cylinders of the pumps are to terminate well above the level of the bilges.

Motive Power of Cargo Oil Pumps.

300. Where the cargo oil pumps are not driven by steam, plans of the arrangements for driving the pumps are to be submitted.

301. Where cargo pumps are driven by shafting which passes through a pump room bulkhead or deck, gas-tight glands with efficient means of lubrication are to be fitted to the shaft at the pump room plating.

Fire Extinguishing Arrangements.

302. The cargo pump rooms are to be provided with a deck operated fire extinguishing system using steam, CO_2 or other suitable medium.

In addition, two portable foam extinguishers are to be provided, one at the pumps and one at the pump room entrance.

71, Fenchurch Street, London, E.C.3.
15th December, 1949.

FIRE EXTINGUISHING ARRANGEMENTS.

These arrangements are at present under revision and in the meantime the following outline requirements are to be complied with so far as they are applicable :—

Wash Deck Service.

(1) An independent power pump is to be arranged to draw from the sea and to deliver water on deck, and the arrangements are to be such that (except in the case of trawlers, tugs, yachts and other small ships) the water service can be used at both ends of the ship at the same time.

Fire Extinguishing Appliances in Ships Burning Oil Fuel.

(2) Steam is to be led to pipes perforated for the emission of steam into the lower parts of the boiler room or other machinery compartments containing oil fuel apparatus or deep storage tanks.

(3) The steam supply to this fire extinguishing apparatus is to be controlled from a readily accessible position outside the compartment.

(4) Where steam fire extinguishing apparatus is not fitted in the machinery spaces of steamers or motorships, equivalent apparatus is to be provided, details of which are to be submitted for approval.

ENGINES AND BOILERS

OF

STEAM SHIPS

INDEX

ENGINES AND BOILERS OF STEAM SHIPS.

B

	Section.	Clause.	Page.
Blow-off and scum valves, size and arrangement	11	1–2	290
Boilers	7	—	288
„ access arrangements	8	—	289
„ annealing of plates	7	4	289
„ baffles at front end plate ...	7	12	289
„ blow-off valves	11	1–2	290
„ butt straps	7	5	289
„ cylindrical shells	15	—	292
„ cross tubes of vertical	8	5	289
„ dampers omitted in oil fired boilers	—	—	259
„ dished plates without stays ...	23	—	298
„ door studs and bolts	8	3	289
„ drilling of rivet holes	7	6	289
„ feed checks	10	9	290
„ flat plates	17	—	294
„ furnaces	16	—	293
„ gauges (water) and test cocks ...	10	1–6	290
„ girders	20	—	296
„ holes for mountings in cylindrical shells	15	6	293
„ hydraulic testing of	9	—	289
„ insulation of	—	—	259
„ jointed longitudinal stays ...	7	11	289
„ manhole, mudhole and sighthole doors	8	1–2	289
„ mountings	14	—	291
„ nuts for screw stays and longitudinal stays	7	9	289
„ plain and stay tubes	22	—	297
„ pressure gauges	10	8	290
„ saturated steam mountings and fittings	14	4	291
„ safety valves	13	—	291
„ „ accumulation test ...	13	6	291
„ salinometer cock or valve ...	10	7	290
„ screw stays	7	8	289
„ scum valves	11	2	290
„ stays	21	—	297
„ steel stays	7	7	289
„ stop valves	12	—	290

	Section.	Clause.	Page.
Boilers, superheated steam mountings and fittings...	14	4	291
„ superheated safety valve and drain cock	14	3	291
„ threads of screw and longitudinal stays	7	10	289
„ tube plates of vertical boilers ...	19	—	296
„ „ under compression ...	18	—	296
„ **Press,** survey of...	—	—	22
„ **Water Tube.**			
GENERAL	24	1	299
deposit receptacles ...	24	7	299
headers and analogous fittings	25	7	300
headers and similar parts, flat surfaces of	25	8	300
longitudinal joints ...	24	5	299
seamless drums	24 25	3 6	299 300
steam drum, protection of ...	24	8	299
MOUNTINGS AND FITTINGS ...	26	1–8	301
accumulation tests ...	26	3	301
feed water fittings	26	6	301
gauges (water)	24 26	4 5	299 301
manholes	26	7	301
safety valves	26	1	301
stop valves	26	4	301
waste steam pipe	26	2	301
TUBES...	27	1–3	301
tests of	28	1–6	302
thickness of	25	4	300
tube ends	25	1	299
„ holes	25	2	299
„ plates	25	5	300
„ „ thinning of ...	25		299
water, inclination of ...	24	6	299
„ welding of plates...	7	2	289

C

Crank Shafts, gauges for testing truth of	5	1(*b*)	286
„ steam engines, diameters for	6	3	286

	Section.	Clause.	Page.
D			
Donkey Boilers of sailing vessels ...	—	2,3	22
Drums, seamless steel for Boilers ...	10A	—	473
E			
Elongation of boiler stay bar test pieces...	5	3(*c*)	468
„ „ steel angle and tee bars	5	3(*b*)	468
„ „ steel test pieces ...	5	3(*a*)	468
„ forging test pieces ...	10	6	472
„ ship steel angle test pieces...	4	3(*b*)	467
„ „ plate test pieces...	4	3(*a*)	467
„ ship steel rivet bar test pieces	6	3	469
„ steel casting test piece ...	9	6	471
„ test pieces of special iron screw stays for combustion chambers... ...	8	2	470
Engines, steam turbine (*see* **Steam turbine engines**)	3	—	285
F			
Forgings, ingot steel, heat treatment of...	10	2&11	472, 473
„ soft in lieu of wrought iron ...	10	6(*b*)	472
„ process of manufacture ...	10	1	472
„ testing and inspection of ...	10	—	472
Funnel Dampers	—	—	259
Furnaces of Boilers	16	—	293
G			
Gauges, crankshafts and turbine engines	5	1(*b*)	286
H			
Hydraulic Testing, boilers, new ...	9	—	289
I			
Ice Navigation, Screw shafts, propeller blades, inlets and discharge valves	6 6	7(*c*) 11	287 288
Inspection of Material, facilities for ...	1	9	465
Installation of Machinery	2	9	285
Insulation of Boilers	—	—	259
Intermediate Shafts, diameters for steam engines	6	2	287
„ diameters for steam reciprocating engines combined with exhaust steam turbines ...	6	14	288
Iron for screw shafts	5	2	286
„ special for screw stays for combustion chambers	8	—	470
L			
Lagging of Boilers	—	—	259
Liners of Screw Shafts	6	8	287
M			
Materials, quality and testing of ...	—	—	465
N			
Novel forms of Construction, machinery and boilers	2	5	285
P			
Periodical Special Surveys	—	—	20
Periodical Surveys, donkey boiler of sailing vessels	—	2,3	22
„ „ exhaust steam turbines connected to the main shafting	—	4(*b*)	21
„ „ boilers and press boilers	—	—	20,22
„ „ water tube boilers ...	—	1	22
Pipes, steam, feed, air and oil pressure, quality and testing of steel for ...	16	—	478
Plans, submission of, steam engines and boilers	2	3	285
Press Boilers, survey of	—	—	22
Pressure Gauges of boilers	10	8	290
Propellers and Propeller Blades, Bronze, testing of	11	—	474
R			
Records in Register Book, machinery and boilers	2	2	285
„ surveys during construction ...	—	6(*d*)	11
Repairs, surveys	—	10	13
S			
Safety Valves of Boilers	13	—	291
Screw Shafts, diameters for steam engines	6	7	287
„ diameters for vessels navigating in ice ...	6	7(*c*)	287
„ liners	6	8	287

	Section.	Clause.	Page.
Screw Shafts, periodical examinations steam engines ...	4	—	20
„ ships intended for notation "Strengthened for Navigation in Ice" ...	6	7(*c*)	287
„ tapering off at forward end	6	7(*b*)	287
Scum Valves	11	2	290
Seamless Steel Drums for Boilers ...	10A	—	473
Shafting, diameters for steam reciprocating engines ...	6	2	287
„ diameters for steam reciprocating engines combined with exhaust steam turbines ...	6	14	288
„ diameters for steam turbine engines and electric propelling motors	6	12	288
„ of steam engines, rules for ...	5	—	286
	6	—	286
„ materials	5	2–4	286
Smoke Box Doors	—	—	259
Smoke Tubes, quality and testing of steel for	16	—	478
Spare Gear, steam reciprocating engines	29	—	302
„ steam turbine engines ...	29	—	303
Special Quality Steel for boilers ...	5	3(*d*)	468
„ „ forgings ...	10	11	473
Special Survey, steam engines, boilers and press boilers	2	1	285
Specification, ship steel	4	1	467
Specifications for propelling machinery...	2	7	285
Steam Engines and Turbines for generators	4	—	286
Steam Pipes, lap welded...	16	2	478
„ seamless	16	2	478
Steam Reciprocating Engines			
„ shafts of ...	5	—	286
„ combined with exhaust steam turbines ...	6	14	288
Steam Turbine Engines and Electric Propelling Motors (*see* **Turbine engines**)	6	12	288
Steel, freedom from defects	1	3	465
„ ingot, soft open hearth	10	6(*b*)	472
„ not produced where rolled ...	1	10	465
„ process of manufacture	1	2	465
„ quality and testing of	1	—	465
„ testing and inspection of	1	4	465
Steel, special quality for shipbuilding ...	7	—	469
„ „ „ boilers	5	3(*d*)	468
„ „ „ for steel forgings	10	11	473
„ tenacity of	1	12	466
Strength, riveted joints in boilers ...	15	—	292
„ tensile boiler material... ...	5	3	468
	8	2	470
„ tensile, ingot steel forgings ...	10	6	472
Superheaters, cast steel mountings ...	14	4	291
„ drain cock	14	3	291
„ safety valve	14	3	291
Survey, vessels not built under the Society's	4	—	25
Surveys, annual or occasional	1	—	15
„ continuous	—	—	12
	4	6	24
„ modified	4	3	24
„ notice of	—	12	13
„ of repairs	—	10	13
„ **Special,** during construction of machinery... ...	—	6(*d*)	11
„ „ steam engines, boilers and press boilers ...	2	1	285

T

Test, bend, description of	3	4	467
„ „ for castings	9	8	471
„ „ forgings...	10	8	473
„ „ special iron for screw stays	8	3	470
„ „ number of, for boiler steel ...	3	2	467
„ forged drums and rotors... ...	10	13	473
„ manufactured rivets	6	—	468
„ material of pressure pipes ...	16	—	478
„ „ „ smoke tubes ...	16	—	478
„ „ „ water tubes ...	27, 28	—	301
„ **tensile,** boiler plates	5	3(*a*)	468
„ „ boiler steel, number of	5	2	468
„ „ special iron for screw stays	8	1, 2	470
„ „ stay bars	5	3(*c*)	468
Thrust Shafts, diameters for steam engines	6	5	287
Turbine Engines, astern wheels... ...	3	—	286
„ diameters of shafts	6	12	288
„ emergency overspeed governors	3	3	286
„ shaft gauges	5	1(*b*)	286
Turbine Engine, spare gear	29	—	303
„ steam and exhaust connections	3	—	286
„ wheel shafts of geared steam	6	13	288

V

Valves, blow off and scum	11	1, 2	290
„ feed check	10	2	290
„ materials	14	4	292
	—	—	269
„ safety	13	—	291
„ salinometer	10	7	290
„ stop, boiler	12	—	290

W

Water Tube Boilers	24	—	299
Welding of boiler plates...	7	2	289

NOTE :—For details regarding pipes and pipe systems *see* **Rules for Pumping and Piping.**

RULES FOR THE CONSTRUCTION AND SURVEY OF ENGINES AND BOILERS OF STEAM SHIPS.

Section 1.

In ships propelled by steam engines, the materials used in the construction of the machinery and boilers are to comply with the **Rules for the Quality and Testing of Materials.** The machinery and boilers are to be inspected throughout, the boilers tested by hydraulic pressure, and the machinery tested under steam by the Society's Engineer-Surveyors, who will furnish a report to the Committee. If found satisfactory the Committee will thereupon grant a certificate, and insert in the Register Book the notation, "LMC" *in red* (*i.e.* "LLOYD'S MACHINERY CERTIFICATE"), indicating that the machinery and boilers are certified to be in good order and safe working condition.

Section 2.

1. In steam ships built under Special Survey, the main and auxiliary engines and boilers, superheaters and economisers (including press boilers and similar apparatus for floating whale-oil factories), steering engines, all pumps, evaporators and feed water heaters and pressure filters intended for essential services and domestic boilers intended for working pressures exceeding 50 lb. per square inch or having heating surfaces greater than 50 square feet are also to be constructed under Special Survey.

2. In cases of machinery or new boilers being built under Special Survey, the distinguishing mark ✠ will be noted in the Register Book *in red*, thus: "✠LMC," or "✠NE&B," or "✠NB."

3. In order to facilitate the inspection, plans in triplicate of the following items are to be submitted for consideration before the work is commenced:—

(*a*) Boilers, superheaters and economisers.
(*b*) Evaporators, feed water heaters and feed water pressure filters.
(*c*) Crank, thrust, intermediate and screw shafting.
(*d*) Reduction gear.

NOTE:—*See* **Rules for Pumping and Piping** for other plans to be submitted.

The plans of machinery space piping are to be diagrammatic.

4. Where it is proposed to depart from the requirements of these Rules, the Committee will be prepared to give consideration to the circumstances of any special case.

5. Any novelty in the construction of the machinery or boilers is to be reported to the Committee.

6. The Surveyors are to examine the materials and workmanship from the commencement of the work until the final test of the machinery under steam; any defects, &c., to be pointed out as early as possible.

7. The Surveyors may also, if desired, compare the work as it progresses with the requirements of the specification agreed upon by the parties concerned, and certify to the conditions thereof, as far as can be seen, being satisfactorily complied with.

8. The cylinders of steam reciprocating engines are to be tested by hydraulic pressure as follows:—

COMPOUND EXPANSION ENGINES:

H.P. Cylinder	... ...	W.P. × 1·5
L.P. Cylinder	... ...	30 lb. per square inch.

TRIPLE EXPANSION ENGINES:

H.P. Cylinder	... ...	W.P. × 1·5
I.P. Cylinder	... ...	W.P. × ·5
L.P. Cylinder	... ...	30 lb. per square inch.

QUADRUPLE EXPANSION ENGINES:

H.P. Cylinder	... ...	W.P. × 1·5
First I.P. Cylinder	...	W.P. × ·6
Second I.P. Cylinder	...	W.P. × ·4
L.P. Cylinders	... ...	30 lb. per square inch.

Where W.P. is the boiler working pressure in lb. per square inch.

Steam Turbines.—The nozzle boxes of impulse steam turbines are to be tested by hydraulic pressure to 1·5 times the boiler working pressure.

The steam casings of all turbines are to be tested by hydraulic pressure to 1·5 times the working pressure in the casing or to 30 lb. per square inch, whichever is the greater.

9. The machinery and boilers are to be securely fixed to the ship to the satisfaction of the Surveyor.

Section 3.

Steam Turbine Engines.—1. In single screw ships fitted with steam turbine engines the arrangements are to be such that steam can be led direct to the L.P. Turbine and either the H.P. or I.P. Turbine can exhaust direct to the condenser.

2. Sufficient astern power is to be provided to maintain adequate control of the ship in all circumstances and for this purpose two astern turbines are to be provided except in single screw ships, where one astern turbine may be fitted.

3. Emergency Overspeed Governors are to be fitted to turbines for main propelling purposes, to prevent the turbines exceeding the maximum designed speed by more than 15 per cent. Where more than one turbine drives on to the same gear wheel, only one of these turbines need be fitted with an emergency overspeee governor. The governors are to be arranged for tripping by hand.

Arrangements are to be made for the steam to the ahead turbines to be automatically shut off in the event of the failure of the lubricating oil system.

Section 4.

Steam engines and turbines intended for driving electric generators are to comply with the requirements of the **Rules for Electric Propelling Machinery, Section 3,** and of the **Rules for Electrical Equipment, Section 2, clauses 1, 13, 14,.17, 18** and **20,** where these are applicable.

For feed, bilge and general service pumps, steam and other pipes, cocks. sea connections; pumping arrangements and forced lubrication *see* **Rules for Pumping and Piping.**

Section 5.

RULES FOR SHAFTS.

1. **General.**—(*a*) All shafts are to be turned all over and are to be examined when rough turned and when finished.

(*b*) Gauges of an approved description for testing the truth of the crank shafts of Reciprocating Engines are to be supplied with all new engines, and adjusted in the presence of the Surveyor. Where Steam Turbine Engines are fitted, gauges for testing the truth of the rotor, pinion and gear wheel shafts are to be supplied, and adjusted in the presence of the Surveyor.

2. **Materials for Shafts.**—(*a*) Shafts may be forged from ingot steel, wrought iron bars piled, or scrap wrought iron, and they may be wrought by hammer, press, or where in straight lengths, by rolling mill.

(*b*) If scrap is used it must be of uniform quality and be thoroughly cleansed. A mixture of iron and steel scrap is not permitted in any case.

(*c*) Where ingot steel is used for shafts it is to comply generally with the requirements of **Section 10** of the **Rules for the Quality and Testing of Materials.**

(*d*) Where ingot steel shafts are made by rolling and the couplings are formed from the shafts by upsetting, the test pieces may be cut from the outer edges of the couplings.

3. **Materials for Couplings.**—(*a*) Couplings of wrought iron shafts may be welded to the body of the shaft, but those of ingot steel shafts are to be forged from the solid or by upsetting the ends by hydraulic pressure.

(*b*) Couplings where separate from the shaft, may be forged from ingot steel or wrought iron ; or they may be steel castings.

4. **Materials for Crank Shaft Webs.**—(*a*) Webs of built crank shafts may be forged or rolled from ingot steel or wrought iron ; or they may be steel castings.

(*b*) The material of rolled or forged steel webs and the test results are to comply with the **Rules for the Quality and Testing of Ingot Steel Forgings,** and the test pieces are to be taken crosswise from the webs as rolled or forged.

(*c*) The material of cast steel webs is to be such that the tensile breaking strength is between the limits of 28 and 35 tons per square inch with a minimum elongation of 20 per cent measured on a standard test piece, and in no case is the sum of the tensile breaking strength and the percentage of elongation to be less than 53.

Section 6.

1. **Dimensions of Shafts.**—The dimensions of the shafts of steam engines are not to be less than those given by the following formulæ. The formulæ do not, however, take into consideration the possibility of severe torsional vibration stresses arising in the shafting and where the circumstances are such as to indicate that critical speeds will occur within the range of working speeds, the sizes of shafting are to be specially submitted for the consideration of the Committee.

With turbine engines situated aft, calculations of the torsional vibration characteristics of the dynamic system formed by the turbine and gearing, line shafting and propeller are to be submitted for consideration, together with plans of all shafting.

2. **Steam Reciprocating Engines.**—The diameter of the intermediate shafts is not to be less than that given by the following formula :—

Diameter of intermediate shaft, in inches =

$$\sqrt[3]{\frac{D^2 \times S \times WP}{C\ (r + 2)}}$$

where **D** is the diameter in inches of the low pressure cylinder or the equivalent diameter where two or more low pressure cylinders are fitted

S is the stroke of the piston in inches,

WP is the working pressure in the boiler in lb. per square inch,

r is the ratio of the areas of the low pressure cylinder or cylinders to that of the high pressure cylinder or cylinders,

C is a coefficient given in the following Table :—

COMPOUND, TRIPLE OR QUADRUPLE EXPANSION RECIPROCATING ENGINES.	VALUES OF "C."	
	Ocean Going and Home Trade Ships.	Ships trading on Estuaries. Rivers, Lochs and Lakes.
2 cranks at 90° ...	1900	2100
2 cranks at 180° ...	1350	1500
3 cranks at 120° ...	2150	2400
4 cranks balanced...	2150	2400
4 cranks at 90° ...	2100	2300

3. **Crank Shafts.**—The diameter of the crank shafts is not to be less than 1·05 times that required for the intermediate shaft.

4. **Crank Webs of Built Shafts.**—(*a*) The dimensions of the crank webs of built shafts are not to be less than those given by the following formulæ :—

$$h = \cdot 625 \times d$$

$$t = \sqrt{\frac{\cdot 12 \times d^3}{h}}$$

where h is the thickness of the web, measured parallel to the axis, in inches,

t is the thickness of metal around the eyeholes, measured radially, in inches,

d is the diameter required for the crank shaft in inches.

(*b*) Crank webs are to be securely shrunk on the body pieces and crank pins. If dowels are not fitted at the junction of the body pieces and webs, the yield point of the material of the webs is to be not less than 14 tons per square inch, and the shrinkage allowance is to be between $\frac{1}{550}$ and $\frac{1}{700}$ of the diameter of the shaft.

5. **Thrust Shafts.**—The diameter at the collars of thrust shafts transmitting torque is not to be less than 1·05 times that required for the intermediate shaft. Thrust shafts may be tapered down outside the collars to the diameter required for the intermediate shaft.

6. **Tube Shafts** (Shafts passing through stern tubes but not carrying the screw propellers).—The diameter of the tube shaft is not to be less than 1·05 times that required for the intermediate shaft, and any part of the shaft within the tube which may be exposed to sea water is not to be less than 1·075 times that required for the intermediate shaft.

7. **Screw Shafts** (Shafts carrying the screw propellers).—(*a*) The diameter of the screw shaft is not to be less than that given by the following formula :—

Diameter of screw shaft, in inches $= d + \frac{P}{C}$

where d is the diameter required for the intermediate shafts, in inches,

P is the diameter of the propeller, in inches,

C = 144 when the shaft is fitted with a continuous liner, or

C = 100 when the shaft is not fitted with a continuous liner.

(*b*) Screw shafts which run in stern tubes may have the end forward of the stern gland tapered down to a diameter, at the coupling flange, of 1·05 times d.

(*c*) Screw shafts for ships intended to have the notation "Strengthened for Navigation in Ice," are to comply with the requirements of **Section 10, clause 8,** of **Rules for Steel Ships.**

8. **Bronze Liners on Shafts.**—(*a*) The thickness of liners fitted on screw shafts or on tube shafts, in way of the bushes, is not to be less than that given by the following formula :—

$$t = \frac{d + 9 \cdot 25}{32}$$

where t is the thickness of the liner, in inches,

d is the diameter required for the screw or tube shaft under the liner in inches.

(*b*) The thickness of a continuous liner between the bushes is not to be less than $\frac{3}{4}$ t.

(*c*) Continuous liners should be cast in one piece or, if made of two or more lengths, the junctions of the separate pieces are to be made by fusion through the whole thickness of the liner.

(*d*) Liners are to be carefully shrunk on, or forced on to the shafts by hydraulic pressure. Pins are not to be used to secure the liners.

(*e*) If the liner does not fit tightly between the bearings in the stern tube, the space between the shaft and the liner is to be charged or forced with a plastic material insoluble in water and non-corrosive.

(*f*) Effective means are to be provided for preventing water from having access to the shaft at the part between the after end of the liner and the propeller boss.

9. **Stern bush.**—The length of the bearing in the stern bush next to and supporting the propeller is not to be less than four times the diameter required for the screw shaft under the liner.

10. **Couplings.**—(*a*) The diameter of the coupling bolts at the joining faces of the couplings is not to be less than that given by the following formula :—

Diameter of coupling bolts, in inches=

$$\sqrt{\frac{d^3}{3{\cdot}5 \times n \times r}}$$

where d is the diameter required for the intermediate shafts, in inches,

n is the number of bolts in the coupling,

r is the radius of the pitch circle of the bolts, in inches.

(*b*) The thickness of the coupling flanges at the pitch circle of the bolt holes is not to be less than the diameter of the coupling bolts at the face of the coupling The thickness of the screw shaft coupling flange is not to be less than 0·25 of the diameter required for the intermediate shaft.

(*c*) The radius of curvature at the fillet where the flange starts from the shaft should not be less than ·125 the diameter of the shaft adjacent to the flange.

(*d*) Where couplings are separate from the shafts provision is to be made to resist the astern pull.

11. **Bronze propellers.**—Where bronze is used for propellers or propeller blades, it is to comply with the requirements of **Section 11** of the **Rules for Quality and Testing of Materials.**

12. **Steam Turbine Engines and Electric Propelling Motors.**—The diameter of the intermediate shafts is not to be less than that given by the following formula :—

Diameter of intermediate shaft, in inches =

$$\sqrt[3]{\frac{SHP}{R} \times F}$$

Where SHP is the maximum designed shaft horse power,

R is the number of revolutions per minute at that power,

F = 64 for ocean going and home trade ships,

F = 58 for ships trading on estuaries, rivers, lochs and lakes.

13. **Wheel Shafts of Geared Steam Turbine Engines.**—(*a*) Where there are two pinions geared into the wheel, opposite, or nearly opposite, to one another, the diameter of the wheel shaft is not to be less than 1·05 times that required for the intermediate shaft.

(*b*) Where there is only one pinion geared into the wheel, or where there are two pinions which are set to subtend an angle at the centre of the shaft of less than 120°, the diameter of the shaft at the wheel and the adjacent journals is not to be less than 1·1 times that required for the intermediate shaft. Abaft the journals the shaft may be tapered to 1·05 times the diameter required for the intermediate shaft.

14.—**Steam Reciprocating Engines combined with Exhaust Steam Turbines.**

Where steam reciprocating engines are combined with exhaust steam turbines, either by means of mechanical gearing or by electric generators and motors, the diameter of the intermediate shafting is not to be less than that given by the following formula, viz. :—

$$d = \sqrt[3]{\frac{SHP \times 64}{R}}$$

where d = diameter of intermediate shaft in inches,

SHP = 0·9 indicated horse-power, of the reciprocating engines when working with the turbine + ·95 shaft horse-power of the exhaust turbine at the turbine shaft,

R = Revolutions per minute of the main propelling shafting.

In no case is the diameter of the intermediate shafting to be less than that required by the Rules for ordinary reciprocating engines when working without a turbine.

15. For dimensions of thrust, tube, and screw shafts, shaft liners, stern bush, shaft couplings and coupling bolts *see* **clauses 5** to **10.**

Section 7.

CYLINDRICAL BOILERS.

1. **General.**—In the design and construction of Marine Boilers the following conditions are to be observed :—

2. Where the joints in the shells of boilers are made by means of welding, the shells are to be constructed in accordance with the **Rules for Welded Pressure Vessels.**

3. Where the joints in the shells of boilers are riveted, the shells are to be constructed in accordance with **Section 15.**

4. All steel plates which are welded, dished, flanged or locally heated are to be afterwards efficiently annealed.

5. Butt straps are to be cut from plates and not from rolled strips.

6. All rivet holes are to be drilled, and as far as possible they are to be drilled in place. After drilling the plates the burrs are to be removed and the faying surfaces of the plates cleaned, and the sharp outer edges of holes also removed.

7. Steel stays are not to be welded. If plus threads are desired, the ends of the stay bars may be upset or the bars may be drawn down in the central portions from bars originally of the size of the ends. In either of these two cases the bars are to be subsequently annealed throughout. In double ended boilers the through longitudinal stays are to be supported at or near the middle of their length.

8. Screw stays of combustion chambers where fitted with nuts, are to be, as far as possible, normal to the chamber plates. Where this is not possible they are to be fitted with taper washers to provide a fair bed for the nuts.

9. Nuts to screw stays in combustion chambers are to be not less than $\frac{3}{4}$ inch thick for stays up to $1\frac{1}{2}$ inches diameter over threads, $\frac{7}{8}$ inch thick for $1\frac{5}{8}$ and $1\frac{3}{4}$ inch stays, 1 inch thick for $1\frac{7}{8}$ and 2 inch stays, and $1\frac{1}{8}$ inches thick for stays over 2 inches in diameter. The nuts are to be made of solid mild steel or of iron which is to be without weld. The nuts for longitudinal stays are to be to the British standards appropriate to the diameters of the stays, the outside nuts having the thickness therein provided for ordinary nuts, and the inside nuts having the thickness provided for lock nuts.

10. Screw stays $1\frac{1}{4}$ inches in diameter and upwards should have 9 threads per inch, and all stays 2 inches in diameter and above passing through plates, and secured by nuts on each side of the plate, should have not more than 6 threads per inch.

11. Where jointed longitudinal stays are fitted between the front and back tube plates they are to be fitted with pins having an effective sectional area not less than 25 per cent in excess of that of the stay. The pins may be slack in the holes, the total slackness being not more than $\frac{1}{16}$ inch. The pins are to be as close as possible to the shoulder of the eye forging. The shoulder of the forging is to to have a diameter not less than 1 inch greater than the diameter of the hole.

12. The end plates in the steam space in way of uptakes are to be shielded from contact with the heated gases.

See paragraphs 117 and 118 **Rules for Pumping and Piping** regarding smoke box doors and the omission of dampers in oil fired boilers.

Section 8.

1. **Access Arrangements.**—(*a*) Manholes in cylindrical shells are to have their shorter axes arranged longitudinally. Where the cylindrical shell is cut for a manhole, compensation is to be provided and is to be such that the strength in way of the hole is not less than that required for the longitudinal joint.

(*b*) Where a flat plate is flanged to stiffen it at a manhole or sight hole, to permit the same working pressure as would be allowed upon an unpierced plate the depth of the flange measured in inches from the outer surface is to be at least equal to $\sqrt{t \times w}$

where t is the thickness of the plate in inches and w is the minor axis of the hole in inches.

2. The doors to manholes, mudholes, and sight holes are to be built up or pressed to shape and annealed, or made from one thickness of plate with a machined recess for the jointing material. Their spigot part or the recess is not to have a greater clearance than $\frac{1}{16}$ inch all round, *i.e.*, the axes are not to be less than $\frac{1}{8}$ inch smaller than the holes in which they are fitted.

3. The studs for securing all doors are to be screwed through the plate, and they are to be fitted with nuts on the inside or bolts may be used screwed through the plate with the heads inside.

4. All boilers are to be provided, where possible, with means for ingress to permit of examination and cleaning of the inner surfaces of plates and tubes exposed to flame. Where the boilers are too small to permit of this there are to be sight holes and mudholes sufficiently large and numerous to permit of the inside being satisfactorily cleaned.

5. Where the cross tubes of vertical boilers are large there is to be a sight hole in the shell opposite to one end of each tube sufficiently large to permit the tube to be examined and cleaned. These sight holes are to be in positions accessible for that purpose.

Section 9.

Hydraulic Tests.—In all new boilers working at pressures up to 100 lb. per square inch the hydraulic test is to be twice the working pressure. For boilers working at pressures greater than 100 lb. per square inch the hydraulic test pressure is to be $1\frac{1}{2}$ times the working pressure plus 50 lb. per square inch.

Section 10.

1. **Water Gauges and Test Cocks.**—Every boiler is to be fitted with at least two independent means of indicating the water level in it, and have marked on it in a contiguous position, easily seen, the level of the highest part of the combustion chamber. One of these means is to be a glass gauge or an equivalent. The other may be a set of test cocks.

(In the case of boilers of tugs, tenders, coasting and other small ships engaged on short voyages, and in that of vertical boilers, the marking of the level of the highest part of the combustion chamber may be omitted.)

2. Test cocks, where practicable, are to be fitted direct on the boiler shell. A set is to consist of at least three cocks except in boilers 7 feet 6 inches in diameter and under when there may be two. For vertical boilers above 7 feet high, the set of test cocks is to consist of at least three.

3. All single-ended boilers, 16 feet mean diameter or over, are to be fitted with a glass water gauge on each side. Single-ended boilers under 16 feet in diameter are to be fitted with one glass water gauge and one set of test cocks, or the equivalent of the latter,

4. All double-ended boilers are to be fitted with a glass water gauge at, or near, each end on opposite sides and a set of test cocks at each end, or the equivalent of the latter.

5. The cocks of all water gauges are to be accessible from positions free from danger in the event of the glass breaking.

6. If the water gauges are not fitted directly to the shell of the boiler but to stand pillars or columns, it is desirable that these pillars or columns should be bolted directly to the shell of the boiler. If they are connected to the boiler by means of pipes the pipes are to be fitted with terminal cocks, not valves, secured direct to the boiler shell. For boilers exceeding 10 feet in diameter the pillars are not to be less than $2\frac{1}{2}$ inches and the connecting pipes not less than $1\frac{1}{2}$ inches internal diameter. For boilers exceeding 7 feet 6 inches but not exceeding 10 feet in diameter the pillars are not to be less than 2 inches and the pipes not less than $1\frac{1}{4}$ inches internal diameter, and for boilers 7 feet 6 inches in diameter and under the pillars are not to be less than $1\frac{3}{4}$ inches and the pipes not less than 1 inch internal diameter. The upper ends of the connecting pipes are to be arranged so that there is no pocket or bend where an accumulation of water from the condensation of the steam can lodge. They should not pass through the uptake if they can be otherwise arranged. If, however, this condition cannot be complied with, they may pass through it by means of a passage at least 2 inches clear of the pipe all round, open for ventilation.

7. A **Salinometer Cock or Valve** is to be fitted direct to each boiler in a convenient position. It must not be on the water gauge stand-pipe.

8. **Pressure Gauges.**—Each boiler is to be provided with a separate steam pressure gauge. Double-ended boilers are to be provided with a pressure gauge at each end. The gauges are to be placed where they are easily seen.

9. **Feed Checks.**—Each boiler is to be fitted with at least two independent means of feed, each with its own check valve. In auxiliary or winch boilers one of the means of feed may be an injector.

Section 11.

1. **Blow-off and Scum Valves.**—Each boiler is to be fitted with a blow-off valve secured direct to the shell. The valve and its connections to the sea need not be more than $1\frac{1}{2}$ inches in diameter, and may be generally about $\frac{1}{10}$ inch in diameter for each foot in diameter of the boiler. It is, however, not to be less than $\frac{3}{4}$ inch in diameter. Vertical boilers are to be fitted with a blow-off cock or valve.

2. Blow-off valves and scum valves (where these latter are fitted) of two or more boilers may be connected to one common discharge, but where thus arranged there are to be screw-down non-return valves fitted for each boiler to prevent the possibility of the contents of one boiler passing to another.

NOTE :—For blow-off cock or valve on ship's side and attachments *see* **Rules for Pumping and Piping.**

Section 12.

Stop Valves.—One main stop valve is to be fitted to each boiler secured direct to the shell. There are to be as few auxiliary stop valves as possible so as to avoid piercing the boiler shell more than is absolutely necessary. The arrangement, however, is to be such that where more than one boiler is fitted it is possible to supply the steam whistle, the steam steering gear, and the electric light machinery from at least two boilers.

Section 13.

Safety Valves. 1.—At least two safety valves are to be fitted to each boiler. They are to be arranged so that the springs and valves are cased in, that the valves cannot be overloaded when steam is up, that they can be lifted by easing gear, and turned round on their seats by hand, and in case of fracture of springs they cannot lift out of their seats. Easing gear is to be arranged to lift all the safety valves on a boiler together, and is to be workable from some accessible place, free from steam danger.

2. Vertical boilers having 100 square feet, or more, of total heating surface are to be fitted with two safety valves each not less than 1·5 inches diameter ; those having less than 100 square feet may have one valve not less than 2 inches diameter.

3. All the safety valves of each boiler may be fitted in one chest, which is to be separate from any other valve chest and is to be connected direct to the boiler by a strong and stiff neck, the passage through which is to be of not less cross sectional area than the aggregate area of the safety valves in the chest in the case of full bore valves and one-half of that area in the case of other valves. Each safety valve chest is to be provided with a means by which it can be drained ; the drain pipe is to be led to the bilge or to a tank, clear of the boiler.

4. (*a*) **Saturated Steam.** The minimum aggregate area of the orifices through the seatings of the safety valves on each boiler, whether coal fired or oil fired, and whether working under natural, forced or induced draught, is to be found by the following formula :—

$$A = \frac{\text{T.H.S.} \times E}{(p + 15) \times C}$$

where A = for ordinary, high lift or improved high lift safety valves, the aggregate area in square inches of the orifices through the seatings of the valves

= for full bore safety valves, the net area in square inches through the seats after deducting the area of the guides or other obstructions when the valves are fully lifted.

T.H.S. = the total external surface in square feet of the tubes and other parts of the boiler exposed to heat, so as to cause evaporation.

p = the working pressure in lb. per square inch.

E = the estimated evaporation in lb. per square foot of heating surface (T.H.S.) per hour, with a minimum value of 6.

C = 4·8 for valves of ordinary type.

= 7·2 for valves of high lift type.

= 9·6 for valves of improved high lift type.

= 19·2 for valves of full bore type.

(*b*) **Superheated Steam.** For valves which have to pass superheated steam, the aggregate area of the valves is to be the area A found above, multiplied by the factor :—

$$\left(1 + \frac{T}{1000}\right)$$

where T = degree of superheat, in degrees Fahrenheit.

(*c*) An approved type of safety valve of equally good and reliable design may be fitted in lieu of those described in the Rules.

5. The waste steam pipe and the passages leading to it are to have a cross-sectional area not less than the aggregate area of the safety valves as given by the foregoing formulae (*a*) and/or (*b*) multiplied by 2·08 for full-bore valves and 1·1 for other valves.

6. All safety valves are to be set under steam to a pressure not greater than 3 per cent. above the approved working pressure of the boiler. During a test of 15 minutes with the stop valves closed and under full firing conditions the accumulation of pressure is not to exceed 10 per cent of the loaded pressure. During this test no more feed-water should be supplied than is necessary to maintain a safe-working water level.

7. For accumulation tests on the safety valves of water tube boilers, *see* **Section 26, clause 3.**

Section 14.

Boiler Mountings. 1.—All Boiler mountings are to be subjected to an hydraulic test of twice the working pressure with the exception of feed check valves which are to be tested to $2\frac{1}{2}$ times the working pressure. The test pressures need not, however, be more than 1,000 lb. per square inch above the working pressure. Valves over $1\frac{1}{2}$ inches diameter are to be fitted with outside screws and the covers are to be secured by bolts or studs. All valves are to be arranged to be shut with a right-hand motion of the wheels.

2. All cocks and valves connected to the boiler are to be such that it is seen without difficulty whether they are open or shut. Where boiler mountings are secured by studs, the studs are to have a full thread holding in the plate for a

length of at least one diameter. If the stud hole penetrates the whole thickness of the plate the stud is to be screwed right through the plate and is to be fitted with a nut inside the boiler. Where bolts are used for securing mountings they are to be screwed right through the plate with their heads inside the boiler.

3. Where a superheater is fitted which can be shut off from the boiler it is to be provided with a separate safety valve fitted with easing gear. The valve as regards construction is to comply with the regulations for ordinary safety valves, but the easing gear may be fitted to be workable from the stokehold only. The superheater is also to be fitted with a drain cock or valve to free it from water when necessary.

4. Safety valve chests and other boiler and superheater mountings subjected to pressures exceeding 150 lb. per sq. inch or to steam temperatures exceeding 425° F. and boiler blow down fittings, are to be made of steel or other approved material.

RULES FOR DETERMINING THE WORKING PRESSURE TO BE ALLOWED IN NEW BOILERS.

NOTE.—Where the joints in the shells of boilers are made by means of welding the shells are to be constructed in accordance with the **Rules for Welded Pressure Vessels.**

Section 15.

RIVETED CYLINDRICAL SHELLS.

1. For the cylindrical shells of steel marine boilers the maximum working pressure (which is designated by WP and is in lb. per square inch) to be allowed is to be calculated from the following formulæ:—

Where the thickness of the shell plates does not exceed $1\frac{3}{4}$ inches.

$$WP = \frac{(t-2) \times S \times J}{C \times D}$$

Where the thickness of the shell plates exceeds $1\frac{3}{4}$ inches, and the longitudinal seams are made with double butt straps.

$$WP = \frac{t \times S \times J}{2{\cdot}85 \times D}$$

In the above formulæ

t is the thickness of the shell plates in 32nds of an inch.

S is the minimum tensile strength of the steel shell plates in tons per square inch.

J is the percentage of strength of the longitudinal seams calculated by the methods described hereafter,

C is a coefficient, which is 2·75 where the longitudinal seams are made with double butt straps, 2·83 where the longitudinal seams are made with lap joints and are treble riveted, 2·9 where they are made with lap joints and are double riveted and 3·3 where they are made with lap joints and are single riveted,

D is the inside diameter of the outer strake of plating of the cylindrical shell measured in inches.

2. The percentage of strength of a riveted joint (J) is found from the following formulæ (i), (ii), (iii): (i) and (ii) are applicable to any type of joint, (iii) is applicable only to that type of joint in which the number of rivets in the inner rows is double that in the outer row. The lowest value given by the application of these formulæ is to be taken as the percentage of strength of the joint.

(i) Percentage of strength of plate at joint as compared with solid plate $= \frac{100\,(p-d)}{p}$

(ii) Percentage of strength of rivets as compared with solid plate.

$$= \frac{100\,(S_2 \times a \times n \times C)}{S_1 \times p \times T}$$

(iii) Percentage of combined strength of the plate at the inner row of rivet holes and of the rivets in the outer row

$$= \frac{100\,(p - 2\,d)}{p} + \frac{100\,(S_2 \times a \times C)}{S_1 \times p \times T}$$

where p = pitch of rivets at outer rows in inches,

d = diameter of rivet holes in inches,

a = sectional area of one rivet in square inches,

n = number of rivets which are fitted in the pitch p,

T = thickness of plate in inches,

C = 1·0 for rivets in single shear as in lap joints

C = 1·875 for rivets in double shear as in double butt-strapped joints,

S_1 = minimum tensile strength of plates in tons per square inch,

S_2 = shearing strength of rivets, which is taken generally to be 23 tons per square inch, and may be 85 per cent. of the minimum tensile strength of the rivet bars.

3. Where the longitudinal seams are fitted with double butt-strapped joints, the outer butt strap is to be at least 0·625 of the strength of the plate, and is to be of sufficient thickness to permit of efficient caulking of its outer edges. The inner butt strap is to be $\frac{4}{32}$ inch thicker than this.

In cases where the number of rivets in the inner rows is double the number in the outer row, this will require the thickness of the outer strap to be

$$t_o = \frac{5 \times (p-d)}{8 \times (p-2\,d)} \times \mathbf{T},$$

and that of the inner strap to be at least

$$t_n = \frac{5 \times (p-d)}{8 \times (p-2\,d)} \times \mathbf{T} + \tfrac{4}{32} \text{ inch.}$$

4. In all cases the clear space between a rivet hole and the edge of a plate is not to be less than the diameter of the rivet holes, *i.e.*, the centre of the rivet hole is to be at least $1\frac{1}{2}$ diameters distant from the edge of the plate.

In joints whether lapped or fitted with butt straps, in which there are more than one row of rivets and in which there is an equal number of rivets in each row, the distance between the rows of rivets is not to be less than 0·33 p + 0·67 d with zigzag riveting, or 2 d with chain riveting.

In joints in which the number of rivets in the outer rows is one-half of the number in each of the inner rows, and in which the inner rows are chain riveted, the distance between outer rows and the next rows is not to be less than 0·33 p + 0·67 d or 2 d, whichever is the greater, and the distance between the rows in which there are the full number of rivets is not to be less than 2 d.

In joints in which the number of rivets in the outer rows is one-half of the number in each of the inner rows and in which the inner rows are zigzag, the distance between the outer rows and the next rows is not to be less than 0·2 p + 1·15 d, and the distance between the rows in which there are the full number of rivets is not to be less than 0·165 p + 0·67 d.

In the above p is the pitch of the rivets in the outer rows.

5. The maximum pitch of the rivets in the longitudinal joints of boiler shells is to be—

Maximum pitch in inches = $\mathbf{C} \times \mathbf{T} + 1\frac{5}{8}$ inches

where $\mathbf{T}$ is the thickness of the plate in inches and $\mathbf{C}$ is a coefficient as given in the following Table :—

Number of Rivets per pitch.	Coefficients for Lap Joints.	Coefficients for Double Butt-strapped Joint.
1	1·31	1·75
2	2·62	3·50
3	3·47	4·63
4	4·14	5·52
5	—	6·00

6. If holes are cut in the cylindrical shells of boilers for fixing of mountings, the diameters of the holes being greater than $2\frac{1}{2}$ times the thickness of the shell plating plus $2\frac{3}{4}$ inches, compensation is to be fitted as in the case of manholes. (*See* **Section 8, clause 1, paragraph** (*a*).)

7. Where more than three screw stays pierce the cylindrical shell in a horizontal line, if d is their diameter and p the pitch, $\frac{100\,(p-d)}{p}$ should not be less than the percentage of strength required for the shell longitudinal joints. If this is not possible, stays are to be arranged out of line with one another longitudinally.

8. The riveting of the seams joining the end plates to the cylindrical shell is not to be less than 42 per cent. of that of the solid shell plate. Where the shell plates exceed $\frac{5}{8}$ inch in thickness the seams connecting the shell plates to the end plates are to be at least double riveted. Where the shell plates exceed $\frac{1}{2}$ inch in thickness the intermediate circumferential seams of double-ended boilers are to be at least double riveted.

9. The circumferential seam at or near the middle of the length of single-ended boilers is to have a strength of joint not less than 60 per cent. of the solid plate. The inner circumferential seams of double-ended boilers are to have a strength of joint not less than 62 per cent. of the solid plate. In any case there are to be at least three rows of rivets where single-ended boilers have shell plates over $1\frac{3}{8}$ inch in thickness and where double-ended boilers have shell plates over $1\frac{3}{16}$ inch in thickness.

10. The circumferential seams of the shells of vertical boilers are to have a strength of not less than 42 per cent. of the solid plate. Where these seams are not complete circles, and where the shell plates exceed $\frac{5}{8}$ inch in thickness, the riveting is to be at least double.

Section 16.

Furnaces.

1. The working pressure to be allowed on corrugated furnaces is to be determined by the following formula :—

$$\mathbf{WP} = \frac{\mathbf{C}\,(t-1)}{\mathbf{D}}$$

where $\mathbf{D}$ is the external diameter measured at the bottom of the corrugations in inches,

t is the thickness of the furnace plate in 32nds of an inch, measured at the bottom of the corrugation or camber,

$\mathbf{C}$ is a coefficient which is 480 for the Fox, Morison, Deighton, Purves, and other similar furnaces, and is 510 for the Leeds Forge Bulb Suspension furnace.

2. The working pressure to be allowed on plain furnaces or furnaces strengthened by the Adamson or other joints, and on the cylindrical bottoms of combustion chambers, is to be determined by the following formulæ, the least pressure obtained by either formula being taken :—

$$WP = \frac{C\,(t-1)^2}{(L+24)\times D}$$

$$\text{or } WP = \frac{C_1}{D} \times [10\,(t-1) - L]$$

where **D** is the external diameter of the furnace or combustion chamber in inches,

t is the thickness of the furnace plate in 32nds of an inch,

L is the length of the furnace or of combustion chamber bottom or the length between points of substantial support, in inches, measured from the centres of rivet rows or from the commencement of flange curvature, whichever is applicable,

C is 1450 where the longitudinal seams are welded and 1300 where they are riveted,

C_1 is 50 where the longitudinal seams are welded and 45 where they are riveted,

WP is the working pressure in lb. per square inch.

3. Where the furnaces are tapered the diameter to be taken for calculation purposes is to be the mean of that at the top, and of that at the bottom where it meets the substantial support from flange or ring. The length for the same purpose is to be the distance from the centre of the row of rivets connecting the crown to the body of the furnace to the substantial support at the bottom of the furnace, or to a row of screwed stays connecting the furnace to the shell, provided the pitch of stays at the furnace does not exceed 14 times the thickness of the furnace plate where the stays are riveted at their ends, and 16 times where they are fitted with nuts. Such screwed stays are to be in diameter over the threads not less than 2·25 times the thickness of the furnace plate.

4. Where the furnaces are spherical in form and convex upwards at their tops, and are without support from stays of any kind :—

$$WP = \frac{275\,(t-1)}{R}$$

where t is the thickness of the top plate in 32nds of an inch,

R is the outer radius of curvature of the furnace in inches.

5. The working pressure to be allowed on internal uptakes of vertical boilers is to be determined by the following formulæ, the least pressure obtained by either formula being taken :—

$$WP = \frac{C\,(t-5)^2}{(L+24)\times D}$$

$$\text{or } WP = \frac{C_1}{D} \times [10\,(t-5) - L]$$

where **D** is the external diameter of the uptake in inches,

t is the thickness of the uptake in 32nds of an inch,

L is the length of the uptake between points of substantial support, in inches, measured from the centres of the rivet rows,

C is 1450 where the longitudinal seams are welded and 1300 where they are riveted,

C_1 is 50 where the longitudinal seams are welded and 45 where they are riveted,

WP is the working pressure in lb. per square inch.

6. The thickness of cross tubes in cross tube boilers shall be determined from the following formula, but shall in no case be less than $\frac{3}{8}$ inch.

$$t = \frac{WP \times D}{200} + 7$$

where t = the minimum thickness in 32nds of an inch,

WP = the working pressure in lb. per sq. inch,

D = the internal diameter of the cross tube in ins.

7. For the ogee ring which connects the bottom of the furnace to the shell, and sustains the whole load on the furnace vertically :—

$$WP = \frac{140\,(t-1)^2}{D \times (D-d)}$$

where t is the thickness of the ogee ring in 32nds of an inch,

D is the inside diameter of the boiler shell in inches,

d is the outside diameter of the lower part of the furnace where it joins the ogee ring in inches.

8. Furnaces, plain or corrugated, are not to exceed $1\frac{3}{16}$ inch in thickness.

Section 17.

Flat Plates supported by Stays secured in various ways.

1. The working pressure to be allowed on flat plates supported by stays is to be calculated by the following formula :—

$$WP = \frac{(t-1)^2 \times C}{a^2 + b^2}$$

In this formula and in that in clauses 8 to 11

WP is the working pressure in lb. per square inch,

t is the thickness of the flat plate in 32nds of an inch,

t_w is the thickness of the washers, strips, or doublings employed also in 32nds of an inch,

a is the distance apart of the rows of stays in inches,

b is the pitch of the stays in the rows in inches,

C is a coefficient which varies with the method of fixing the stays as follows :—

Where the plates are exposed to flame and the stays are screwed into the plate and their ends are riveted over **C** = 50. Where the plates are not exposed to flame and the stays are screwed into the plate and their ends are riveted over **C** = 57. In these cases the thickness of the plate is to be at least half the diameter of the stay required by the Rules.

Where stay tubes are screwed into tube plates and expanded **C** = 52. If they are fitted with nuts **C** = 72.

Where the plates are exposed to flame and the stays are screwed into the plate and fitted with nuts on the outside **C** = 75. Where the plates are not exposed to flame **C** = 86.

Where the stays pass through the plates not exposed to flame and are fitted with nuts inside and outside **C** = 96, and where the plates are exposed to flame **C** = 84.

2. Where plates are stiffened by flanging, the inner radius of which is not greater than $2\frac{1}{2}$ times the thickness of the plate, for the support thus given **C** = 110 where the plates are not exposed to flame and **C** = 96 where they are exposed to flame. The pitch is to be reckoned from the commencement of the curvature.

3. For portions of plate where the stays are irregularly pitched d^2 is to be used instead of $a^2 + b^2$, d being the diameter of the largest circle which can be drawn passing through not less than three points of support, viz., the centres of stays or the commencement of the curvature of flanging whichever is applicable. In this case **C** is to be taken as the mean of the values appropriate for the points of support.

4. For the tops and sides of combustion chambers the distance between the rows of stays nearest to the back tube plate or the back plate respectively and the commencement of curvature of these plates at their flanges is not to be greater than a.

5. The stays of the combustion chambers are to be so placed that the seams of the plates can be caulked without removing the stay nuts.

6. For the tops of combustion chambers where they are joined to the sides by curved portions, if the outer radius of the curved portion is less than half the allowable distance between the girders, the distance between the first girder and the inner surface of the side plate is not to exceed the allowable distance between the girders. If the radius of the curved portion is greater than half the allowable distance between the girders, the width of the flat portion measured from the centre of the girder is not to be more than half the allowable distance between the girders.

7. Where portions of plate are supported by stays secured in different ways the value of **C** to be taken is the mean of the values appropriate to the method of securing the supporting stays.

8. Where the plates are supported by stays passing through them and are fitted with nuts inside and washers and nuts outside, the diameter of the washers being at least 3·5 times that of the stay, and their thickness at least two-thirds of that of the plate but not greater than that of the plate :—

$$WP = \frac{100}{a^2 + b^2}[(t - 1)^2 + 0{\cdot}15\ t_w^2]$$

9. Where the washers have a diameter of at least two-thirds of the pitch of the stays and a thickness of at least two-thirds of the thickness of the plate but not greater than that of the plate and are riveted to the plate in an efficient manner :—

$$WP = \frac{100}{a^2 + b^2}[(t - 1)^2 + 0{\cdot}35\ t_w^2]$$

10. Where the plate is stiffened by strips at least two-thirds of the pitch of the stays in breadth and having a thickness at least two-thirds of that of the plate but not greater than that of the plate and are riveted to the plate in an efficient manner :—

$$WP = \frac{100}{a^2 + b^2}[(t - 1)^2 + 0{\cdot}55\ t_w^2]$$

11. Where the plates are fitted with doubling plates having a thickness of at least two-thirds of that of the plate but not greater than that of the plate and are riveted to them :—

$$WP = \frac{100}{a^2 + b^2}[(t - 1)^2 + 0{\cdot}85\ t_w^2]$$

12. For the portions of tube plates in the nests of tubes :—

$$WP = \frac{C\,(t-1)^2}{p^2}$$

where t is the thickness of the tube plate in 32nds of an inch,

p is the mean pitch in inches of the stay tubes supporting any portions of the plate (being the sum of the four sides of the quadrilateral divided by 4),

C = 38 where the stay tubes are screwed and expanded into the plate and nuts are not fitted,

C = 49 where the stay tubes are screwed and expanded into the plates and fitted with nuts.

13. For the wide water spaces of front tube plates between the nests of tubes and between the wing rows of tubes and the shell :—

$$WP = \frac{C[(t-1)^2 + 0{\cdot}55t_w^2]}{a^2 + b^2}$$

where t is the thickness of the front tube plate in 32nds of an inch,

t_w is the thickness of the doubling plate, where so fitted in 32nds of an inch,

a is the horizontal pitch of stay tubes in inches measured across the wide water space,

b is the vertical pitch of stay tubes in the bounding rows, in inches, measured from centre to centre,

C = 52 where the stay tubes are screwed and expanded into the tube plate and nuts are not fitted,

C = 72 where the stay tubes are screwed and expanded into the tube plates, and nuts are fitted to each stay tube,

C = 63 where the stay tubes are screwed and expanded into the tube plates, and nuts are fitted only to alternate stay tubes.

14. If steel of less strength than 26 tons per square inch is used for flat plates, the working pressure allowed is to be correspondingly reduced.

Section 18.

Tube Plates under Compression.

The pressure to be allowed on tube plates is to be calculated by the following formula, in which the compressive stress is taken at 14,000 lb. per square inch :—

$$WP = 875 \times \frac{(D-d) \times t}{W \times D}$$

where t is the thickness of the tube plate in 32nds of an inch,

D is the horizontal distance apart of the tubes centre to centre in inches,

d is the internal diameter of the plain tubes in inches,

W is the width of combustion chamber in inches measured inside from tube plate to back chamber plate, or between tube plates in double-ended boilers with combustion chambers common to two opposite furnaces.

Section 19.

Tube Plates of Vertical Boilers.

Where vertical boilers have a nest or nests of horizontal tubes so that there is direct tension on the tube plates due to the vertical load on the boiler ends or to their acting as horizontal ties across the shell, the thickness of the tube plates and the spacing of the tubes are to be such that the section of metal taking the load is sufficient to keep the stress within that allowed on the shell plates.

Further, each alternate tube in the outer vertical rows of tubes is to be a stay tube. The tube plates between the stay tubes are to be in accordance with the rules for tube plates as in **Section 17, clause 12,** and in addition

$$WP = \frac{(t-2) \times S \times (p-d) \times 100}{2{\cdot}9 \times D \times p}$$

where S is the minimum tensile strength of the steel plate in tons per square inch,

t is the thickness of the tube plate in 32nds of an inch,

D is twice the radial distance of the centre of the outer row of tube holes from the axis of the shell in inches,

p is the vertical pitch of tubes in inches,

d is the diameter of the tube holes in inches.

Section 20.

Girders.

For girders supporting the tops of combustion chambers the following formula is to be used :—

$$WP = \frac{C \times d^2 \times t}{(L-P) \times D \times L} \times \frac{S}{28}$$

where d is the depth of the girder at centres in inches ;

t is the thickness of the girder at centre, where this is a forging, or the sum of the thicknesses of the plates where the girder is made of two plates, measured in 32nds of an inch ;

L is the length of the girder in inches, measured between the tube plate and back chamber plate inside, or between tube plates in chambers common to two opposite furnaces;

P is the pitch of stays supported by the girder, in inches;

D is the distance apart of the girders, centre to centre, in inches;

S is the minimum tensile strength of the steel plates forming the girder, in tons per square inch. In the case of forged girders **S** is to be taken as 24 for iron and 28 for steel;

C is a coefficient as follows:—

$$C = \frac{n}{n+1} \times 495,$$

where the number of stays in each girder is odd,

$$= \frac{n+1}{n+2} \times 495,$$

where the number of stays in each girder is even, n being the number of stays to each girder.

Section 21.

STAYS.

1. For screw stays with threads not coarser than 9 threads per inch, made of steel or of special wrought iron tested to the requirements of the Rules (*see* **Section 8** of the **Rules for the Quality and Testing of Materials**), the following formula is to be used, but in no case is the stress to exceed 9,000 lb. per square inch:—

$$WP = \frac{(d - 0{\cdot}267)^2 \times 8250}{a}$$

where d is the diameter of the stay over the thread in inches,

a is the area in square inches supported by one stay.

2. For steel longitudinal stays with threads not coarser than 6 threads per inch the working pressure is to be calculated from the following formula, but in no case is the stress to exceed 11,000 lb. per square inch where steel of a minimum tensile strength of 28 tons per square inch is used:—

$$WP = \frac{(d - 0{\cdot}340)^2 \times 9500}{a} \times \frac{S}{28}$$

where d is the diameter of the stay over the thread in inches,

a is the area in square inches supported by one stay,

S is the minimum tensile strength of the steel in tons per square inch.

3. In cases where longitudinal stays are made with enlarged ends and the body of the stay is smaller in diameter than at the bottom of the thread, and in cases where coarser threads than 6 per inch are used the working pressure is to be calculated from the following formula:—

$$WP = \frac{(d^1 - 0{\cdot}125)^2 \times 9500}{a} \times \frac{S}{28}$$

where d^1 is the diameter of the stay at the bottom of the thread or at the smallest part of the body.

Section 22.

BOILER TUBES, PLAIN AND STAY.

1. Where smoke tubes are made of steel, the material is to comply with the requirements of **Section 16** of the **Rules for Quality and Testing of Materials.**

2. (*a*) The tolerance in thickness shall be 10 per cent below and 10 per cent above the specified thickness.

(*b*) The external diameter of the tubes, measured at any point, shall be within the following tolerances of the diameter ordered.

For tubes under $2\frac{1}{2}$ inches outside diameter:—

$+ \frac{1}{64}$ inch.

$- \frac{1}{32}$ inch.

For tubes $2\frac{1}{2}$ inches outside diameter and larger:—

$\pm$ 1 per cent.

3. The following Table gives the working pressures permissible with plain boiler tubes of standard thicknesses, whether of lapwelded wrought iron or of lapwelded or seamless mild steel:—

Outside Diameter of tube in inches.	Standard thicknesses in L. S. G.				Working pressures in lb. per sq. inch.			
	A	B	C	D	A	B	C	D
2		11	10	9		155	215	300
$2\frac{1}{4}$	11	10	9	8	140	190	260	315
$2\frac{1}{2}$	11	10	9	8	125	175	230	300
$2\frac{3}{4}$	11	10	9	8	110	160	215	275
3	10	9	8	7	140	190	250	300
$3\frac{1}{4}$	10	9	8	7	130	180	230	280
$3\frac{1}{2}$	10	9	8	7	120	165	215	260

4. On stay tubes, whether of wrought iron or of steel, a working stress of 7,500 lb. per square inch of the net sectional area at the bottom of the thread is allowed.

5. The minimum thickness of stay tubes measured under the threads is to be $\frac{1}{4}$ inch for marginal stay tubes and $\frac{3}{16}$ inch for other stay tubes.

6. Stay tubes are to be screwed at both ends with continuous threads, and the holes in the tube plates are to be tapped with continuous threads. The pitch of the thread is not to be finer than 10 threads per inch. It is desirable however that they should be screwed to the standard 9 threads per inch. The stay tubes are to be expanded by roller expanders and not made tight by caulking only.

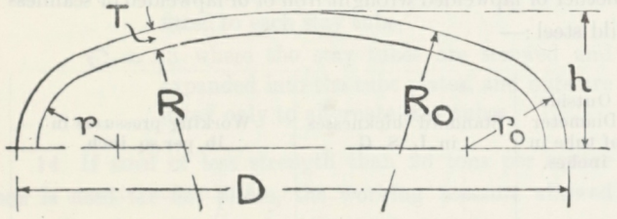
7. Nuts are not to be fitted to stay tubes at the combustion chamber end.

8. If stay tubes are increased in thickness at the screwed ends so that the thickness at the bottom of thread is practically the same as in the body of the tube, the thickening is to be attained by upsetting and not by any welding process, and the tubes are to be annealed after the upsetting.

Section 23.

Dished Plates without Stays.

1. For ends of boiler drums and receivers, crowns of vertical boilers and other similar plates dished to partial spherical form subject to pressure on the concave side, but not exposed to flame, and having no unreinforced opening greater than four times the thickness of the plate, the required thickness of plate is to be determined by formula (*a*) or (*b*).



$$(a)\ WP = \frac{4726 \times S \times h}{D'} \left\{ \frac{\frac{r}{R} + 0{\cdot}05}{\frac{r}{R} + 0{\cdot}15} \right\} \times (T - 0{\cdot}03)$$

$$(b)\ WP = \frac{480 \times S(T - 0{\cdot}03)}{R}$$

where T = thickness of the end in inches after dishing, but in no case to be less than the thickness of a seamless unpierced shell of the same diameter and material.

WP = working pressure in lb. per square inch.

S = minimum tensile strength of the material in tons per square inch.

D = outside diameter of drum end in inches.

R = inside radius of curvature of end in inches which is not to exceed D.

r = inside corner radius in inches.

h = external height of dishing in inches measured from the centre of the inside corner radius and may be determined as follows:—

$$h = R_o - \sqrt{\left(R_o - \frac{D}{2}\right)\left(R_o + \frac{D}{2} - 2r_o\right)}$$

where R_o = outside radius of curvature of the end in inches.

r_o = outside corner radius in inches.

The inside corner radius "r" is not to be less than four times the thickness of the end plate and in no case less than 2·5 inches.

2. Proposals to make dished end plates of semi-elliptic form will be considered provided full details are submitted before the work is commenced.

3. Where the end is provided with a flanged manhole the thickness of the end in inches obtained by the foregoing formulae is to be increased by $\frac{1}{8}$ inch and the depth of the manhole flange, measured in inches from the outer surface at the minor axis shall be not less than

$$F = \sqrt{T_1 \times W}$$

where T_1 = the required thickness of the end plate in inches.

W = the minor axis of the manhole in inches.

4. Where the end is provided with large openings for branches, mountings, or unflanged manholes the thickness of the end as determined by the foregoing formulae, shall be increased by $\frac{1}{8}$ inch and adequate compensation shall be provided, at least equivalent to the cross sectional area obtained by multiplying the diameter or major axis of the opening cut in the end plate by the thickness required for an equivalent unpierced end.

5. Where the end is provided with small openings greater than four times the thickness of the end plate, local compensation is to be provided.

6. Where the end or crown is a complete hemisphere without stays or other supports, and is made in more than

one plate, the working pressure to be allowed is given by the following formula :—

$$WP = \frac{(t - 2)\ S \times J}{C \times R}$$

where t is the thickness of the plates in 32nds of an inch,

S is the minimum tensile strength of the steel plates in tons per square inch,

J is the strength of riveted joint per cent of the solid plate,

R is the inner radius of curvature, in inches,

C is a coefficient which for treble riveting is 2·83, for double riveting is 2·9, and for single riveting is 3·3.

Section 24.

WATER TUBE BOILERS.

1. **General.**—Water tube boilers are, as regards construction, and the quality and tests of the material used in their construction, to comply with the general **Rules for Cylindrical Boilers,** except as hereinafter specified; and they are to be so designed as to ensure water circulation over every part of surfaces exposed to flame when working under service conditions.

2. **Welded Drums.**—Where the joints in the drums of boilers are made by means of welding, the drums are to be constructed in accordance with the **Rules for Welded Pressure Vessels.**

3. **Seamless Drums.**—Where seamless steel drums are used, the drums are to be made in accordance with **Section 10A** of the **Rules for the Quality and Testing of Materials.**

4. **Water Gauges.**—The position of the glass water gauges of boilers in which the tubes are entirely drowned when cold is to be such that water is just showing in the glass when the water level in the steam drum is just above the top of the uppermost tubes when the boiler is cold. In boilers, the tubes of which are not entirely drowned when cold, the glass water gauges are to be placed, to the Surveyor's satisfaction, in the positions which have been found by experience to indicate satisfactorily that the water content is sufficient for safety when the boiler is worked under all service conditions.

5. **Longitudinal Joints.**—The longitudinal joints of the cylindrical drums of water tube boilers, the internal diameters of which are less than 100 times the thickness of the plating at the joints, are not to be of ordinary riveted lapped type, but are to be such as to maintain internal circularity of section.

6. **Inclination of Water Tubes.**—The tubes which connect the drums or headers, and are the means for circulating the water when generating steam, are to be set at an inclination of not less than 15 degrees from the horizontal, but in the case of boilers where each tube is in series with one or more tubes so as to form a continuous run, the inclination need not exceed 5 degrees.

7. **Deposit Receptacles.**—It is desirable that provision should be made in the design so that solid matter in the water can be deposited automatically without danger arising from such matter collecting on parts exposed to heat.

8. **Protection of Steam Drum.**—Where the bottom of the steam drum is exposed to radiation from the fire, or to the impact of hot gases, and it is not protected by the tubes, a shield of good refractory material whose conductivity is low is to be fitted, or the tube plate is to be suitably thinned at this part.

Section 25.

CONSTRUCTION OF WATER TUBE BOILERS.

1. **Tube Ends.**—All tubes are to be carefully drifted or roller expanded in the holes in the tube plates. They are to project through the neck or bearing part in the holes by at least a $\frac{1}{4}$ inch. They are to be secured from drawing out at each end, and if this is done by bellmouthing only, the bellmouthing is to be $\frac{1}{32}$ inch for each inch in external diameter plus $\frac{2}{32}$ inch. That is, the increase of diameter at the outer end of the bellmouth for a tube of 1 inch in diameter is to be $\frac{3}{32}$ inch, for a 2 inch tube $\frac{4}{32}$ inch, and for a 3 inch tube $\frac{5}{32}$ inch.

2. **Tube Holes.**—(*a*) The tube holes in the tube plates of drums, pockets or headers are to be formed in such a way that the tubes can be effectively tightened in them. Where the tube ends are not normal to the tube plates, there is to be a neck or belt of parallel seating of at least $\frac{1}{2}$ inch in depth measured in a plane through the axis of the tube at the holes.

(*b*) Where the tubes are practically normal to their plates, this parallel seating is not to be less than $\frac{3}{8}$ inch in depth.

3. **Thinning of Tube Plates.**—Where the tube plates are reduced in thickness for the purpose of jointing either by lapping or by the fitting of butt straps, or in order to receive the drum end flanges, such reductions are to be gradual and carefully machined to size.

4. **Thickness of Tubes.**—(*a*) For pressures up to 250 lb. per square inch, the minimum thickness of tubes is to be calculated by the following formulæ :—

For the two rows of tubes next the fire and round the gaps formed in the nests of tubes for the outflow of the hot gases from the fire :—

$$t = \frac{WP \times d}{55} + 7$$

For all other tubes, including superheater tubes :—

$$t = \frac{WP \times d}{75} + 7$$

(*b*) For pressures above 250 lb. up to 650 lb. per square inch, and a designed steam temperature not exceeding 750° F., the minimum thickness of the tubes is to be calculated by the following formulæ :—

For the two rows of tubes next the fire and round the gaps formed in the nests of tubes for the outflow of the hot gases from the fire :—

$$t = \frac{d}{200}(WP + 400) + 9$$

For all other tubes, including superheater tubes :—

$$t = \frac{d}{200}(WP + 400) + 6$$

where **WP** is the working pressure in lb. per square inch,
d is the external diameter in inches,
t is the thickness in 100ths of an inch.

The maximum thickness of any tube is not to exceed 1 S.W.G. (0·3 inch).

5. **Tube Plates.**—Where tube plates form portions of cylindrical drums, their thickness in way of the tube holes is to be calculated by the following formula :—

$$t = \frac{WP \times C \times D}{S \times J} + 4$$

$$\text{or } WP = \frac{(t-4)\ S \times J}{C \times D}$$

where **D** is the internal diameter of the drum in inches
t is the thickness of tube plates in 32nds of an inch,
S is the minimum tensile strength of the plate forming the drum in tons per square inch,
J is the percentage strength of the plate through the tube holes, viz. :— $\frac{p-d}{p} \times 100$,
p is the pitch of the tubes in inches on lines parallel with the axis of the drum,
d is the diameter of the tube holes in inches,
C = 3.

6. **Seamless Drums.**—For seamless steel drums the maximum working pressure to be allowed for the cylindrical shell clear of the tube holes is to be determined by the following formula :—

$$WP = \frac{35 \times S \times (t-2)}{D}$$

where **WP** = the working pressure in lb. per square inch.
S = the minimum tensile strength of the material in tons per square inch.
t = the thickness of the shell in 32nds of an inch.
D = the internal diameter of the cylindrical shell in inches.

7. **Headers and Analogous Fittings.**—These may be of wrought or cast steel, or of such other material as may be approved. If wrought steel is used, the material is to comply with the **Rules for the Quality and Testing of Materials.** If cast steel is used, the material is to comply with the aforementioned rules, or, alternatively, with the British Engineering Standards Specification for Grade C Cast Steel, which prescribes an elongation of not less than 15 per cent, measured on the Standard test piece, and a bend test through 90 degrees, without fracture of the test piece, the internal radius of the bend being not greater than 1 inch.

8. **Flat Surfaces of Headers and Similar Parts.**—(*a*) Where flat surfaces of headers or similar parts are not pierced for tubes, the thickness of such parts is not to be less than that given by the following formula :—

$$t = b \times \sqrt{\frac{WP}{C}} + 3$$

$$\text{or } WP = \left(\frac{t-3}{b}\right)^2 \times C$$

where t is the thickness in 32nds of an inch,
b is the breadth (in inches) of the flat surface measured from support to support inside,
C = 81 for wrought steel,
C = 64 for steel castings.

(*b*) The thickness of the headers at the tube holes in 32nds of an inch is not to be less than

$$t = 3 \times \sqrt{d} + 8$$

where d is the diameter of the hole in inches.

(*c*) The headers in way of the sighting doors are to be machined to give true and fair faces for the doors to joint upon. The thickness where machined may be as much as $\frac{3}{32}$ inch less than given by the above rule, but generally it is not to be less than $\frac{19}{32}$ inch.

(*d*) The thickness of all headers which are exposed to radiation from the fire, or to the impact of hot gases, and which have only steam within them under service conditions, as is the case with superheaters, is to be 12·5 per cent greater than that given by the above formula.

(*e*) The sighting hole doors are to be substantial, and capable of being removed and replaced from time to time without loss of efficiency or safety. Where they are held in place by bolts, the doors are to be so designed that they will not blow out in the case of the breakage of the bolt or otherwise.

(*f*) Every flange is to have a fillet with a radius not less than the thickness of the neck to which it is attached.

Section 26.

Boiler Mountings and Fittings for Water Tube Boilers.

1. **Safety Valves.**—(*a*) The safety valves are to be in number, area, design and ordinary construction, in agreement with **Section 13** of the **Rules for Cylindrical Boilers.**

(*b*) An approved type of safety valve of equally good and reliable design may be fitted in lieu of those described in the Rules.

2. **Waste Steam Pipe.**—The waste steam pipe and passages leading to it from the safety valves are to be in accordance with the requirements of **Section 13, clause 5.**

3. **Accumulation Tests.**—(*a*) Tests for accumulation of pressure are to be carried out with the stop valve closed and under full firing conditions for as long a time as the water supply in the boiler permits, but in no case need they exceed 7 minutes in duration. The accumulation is not to exceed 10 per cent of the working pressure.

(*b*) In the case of oil fired boilers, where accumulation tests might endanger the superheaters, consideration will be given to the omission of these tests, if an application to this effect is received when the plans of the boilers are first forwarded for approval.

In order that the omission of the accumulation tests may be approved, it will be necessary for the safety valves to be of a size and type for which the Society's approval has been given after initial capacity tests have been carried out at the Maker's works to the satisfaction of the Surveyors.

Subsequently, the Makers are to provide a Certificate for each valve to the effect that it is of an approved type and is capable of passing the necessary quantity of steam at the approved working pressure of the boiler and at its maximum rating as certified by the Makers of the boiler.

The areas of the valves are not, in any case, to be less than required by **Section 13, clause 4.**

The safety valves are to be found satisfactory in operation under full working conditions during the trials of the machinery on board ship.

4. **Stop Valves.**—Where two or more boilers are connected together, stop valves of self-closing or non-return types are to be fitted.

5. **Water Gauges.**—There are to be at least two water gauges to each boiler, fitted in such a way as to be quite independent of each other. One of them is to be a glass water gauge, while the other may be an equivalent; but where water and steam drums exceeding 13 feet in length are fitted athwartship a glass water gauge is to be fitted at or near each end of the drum.

6. **Feed Water Fittings.**—(*a*) Each boiler is to be fitted with at least two distinct and independent feed systems, each with its own check valve attached direct to the boiler. At least one of these systems is to be fitted with an approved apparatus whereby the supply is controlled automatically.

(*b*) The feed check valves are to be fitted with efficient gearing, whereby they can be satisfactorily worked from the stokehold floor, or other convenient position.

7. **Manholes.**—In all the drums, manholes are to be provided of such size as to permit of access for internal examination, and for the satisfactory fitting of all the tubes in place.

8. **Mountings and Fittings.**—Those not referred to in this Section are to be in accordance with **Sections 10, 11, 12 and 14,** of the **Rules for Cylindrical Boilers.**

Section 27.

Tubes for Water Tube Boilers.

1.—All tubes subject to internal pressure are to be solid drawn and made of steel produced by an open-hearth process, acid or basic, the ultimate tensile strength of which

does not exceed 28 tons per square inch, and the elongation of which is not to be less than 30 per cent on a Standard Test Piece C (British Standards Institution Test Piece F), when in the billet or bar form, and is to be certified as such by the makers of the steel and of the tubes.

2. All tubes under $1\frac{1}{2}$ inches external diameter are to be cold finished; these, and all other cold-drawn tubes, are to be satisfactorily annealed before examination.

3. All tubes are to be free from defects, both within and without.

Section 28.

Tests of Tubes for Water Tube Boilers.

1.—All tubes up to 10 L.S.G. in thickness are to be capable of being flattened by hammering when cold until the inner surfaces are not further apart than $\frac{2}{32}$ inch. For those over 10 L.S.G., and not exceeding 6 L.S.G., the maximum distance apart is to be $\frac{7}{32}$ inch; for those over 6 L.S.G., and not exceeding 3 L.S.G., the maximum distance apart is to be $\frac{12}{32}$ inch; and for those whose thickness exceeds 3 L.S.G., the maximum is to be $\frac{18}{32}$ inch. In all cases after undergoing such tests there are not to be any signs of cracking or other fracture.

2. All tubes when cold are to be able to withstand, without cracking, an enlargement of diameter at both ends by means of roller expanders, or by drifts to the extent of:—

Thickness of Tubes.	Enlargement of Diameters at Ends by means of	
	Roller Expanders.	Drifts.
Up to 10 L.S.G.	12·5 per cent	9·5 per cent
Above 10 L.S.G. & up to 6 L.S.G.	9·5 per cent	7·0 per cent
Above 6 L.S.G.	6·5 per cent	5·5 per cent

3. (*a*) Tubes should be presented for test in batches of 100 each. Two tubes are to be selected indiscriminately from each of at least two batches, and one from each of any remaining batches. Each tube so selected is to be subjected to the above expanding tests, and one tube from each batch, which may be a tube that has sustained the expansion test, is also to be flattened cold to the extent specified in **clause 1** at three different parts of its length, of which one position is to be at or near the middle of the tube, and the flattened portions are to be in three different planes. The tubes are to pass these tests without signs of cracking.

(*b*) Should one of the selected tubes fail to withstand either of these tests, two further tubes are to be selected from the batch and be subjected to both the prescribed tests. If further failure occurs the particular batch of tubes is to be rejected as unsatisfactory.

4. (*a*) Every tube is to be tested at the Tube Maker's Works by hydraulic pressure to not less than 1,000 lb. per square inch.

(*b*) Downcomer tubes are to be tested as required for steam pipes.

5. The manufacturer's certificate of the results of the foregoing tests may, at the discretion of the Surveyor, be accepted provided each tube is delivered with 1 inch in excess of the finished length, which excess is to be partly severed for flattening to the extent prescribed in **clause 1.**

6. Every tube delivered is to be straight (unless otherwise specified) and is to be practically concentric throughout its length. The tolerance or deviation from the specified thickness is to be within the following limits:—

(*a*) **Cold Finished Tubes.**—The tolerance in thickness shall be 5 per cent below and 10 per cent above the specified thickness.

(*b*) **Hot Finished Tubes.**—The thickness of the tubes shall be within the following tolerances, measured at any point:—

From $1\frac{1}{2}$ inches up to and including $2\frac{1}{2}$ inches... ... ... { — $7\frac{1}{2}$ per cent. + $17\frac{1}{2}$ „ „

Over $2\frac{1}{2}$ inches up to and including $4\frac{1}{2}$ inches... ... ... { — 5 per cent. + 15 „ „

Over $4\frac{1}{2}$ inches ... ... { — $7\frac{1}{2}$ per cent. + $17\frac{1}{2}$ „ „

The tolerances in external diameter from those specified are to be as follows:—

(*a*) **Cold Finished Tubes.**—The external diameter of the tubes, measured at any point, shall be not greater than that specified, but may be less by a maximum of 1 per cent.

(*b*) **Hot Finished Tubes.**—The external diameter of the tubes, measured at any point, shall be within the following tolerances of the diameter ordered:—

For tubes from $1\frac{1}{2}$ inches but below $2\frac{1}{2}$ inches... ... ... { + $\frac{1}{64}$ inch. — $\frac{1}{32}$ „

For tubes $2\frac{1}{2}$ inches diameter and over... ± 1 per cent

Section 29.

Spare Gear.

In ships engaged on ocean going service and fitted with Steam Reciprocating Engines the articles mentioned

in the following list (so far as they are applicable) will be required to be carried, viz. :—

*For a single-screw ship a propeller, or two blades with studs and nuts for one blade. The propeller or blades may be of cast iron, except for ships having the notation "Strengthened for Navigation in Ice."

1 complete bottom end bearing.

1 complete top end bearing.

*1 set of metallic packing complete for each size of main piston rod.

*1 set of coupling bolts of each size used.

1 set of pads of each hand for one face of Michell thrust block.

1 set of feed and bilge pump valves and seats where these pumps are worked by the main engines.

1 set of valves of each size used for the liquid end of each independent pump.

1 set of air pump valves.

1 set of circulating pump valves.

1 valve lid for main feed check for one boiler.

*1 impeller shaft for main circulating pump.

1 set of rings for H.P. piston.

1 set of rings for H.P. piston valve.

1 valve of each size with springs and rollers where poppet valves are used on the main engines.

12 boiler tube stoppers complete.

A set of fire bars for one furnace.

1 set of oil fuel burner nozzles complete with atomisers, etc., for one boiler.

A quantity of assorted bolts, studs and nuts. Steel bars and plates of various sizes.

Spare Gear for Steam Turbine Engines.

In ships engaged on ocean going service and fitted with Steam Turbine Engines the articles mentioned in the following list (so far as they are applicable) will be required to be carried, viz. :—

*For a single screw ship a propeller, or two blades with studs and nuts for one blade. The propeller or blades may be of cast iron, except for ships having the notation "Strengthened for Navigation in Ice."

1 set of coupling bolts of each size used.

*1 complete bearing bush of each size used for main gear wheel shaft.

1 complete bearing bush of each size used for rotor shaft.

1 complete bearing bush of each size used for pinion shaft.

1 half set of packing rings or segments for each gland of rotor shafts so fitted, and half the number of springs fitted.

2 ordinary thrust shoes for main thrust block or sufficient pads for one face of Michell type of main thrust block of each hand.

Turbine thrust and adjusting bushes with rings complete (or one set of pads of each hand for Michell type) for one turbine of each size fitted.

1 set of liners for adjusting block of different thicknesses.

1 set of valves of each size used for the liquid end of each pump.

1 valve lid for main feed check for one boiler.

*1 impeller shaft for main circulating pump.

12 boiler tube stoppers complete.

1 set of fire bars for one furnace.

1 set of oil fuel burner nozzles complete with atomisers, etc., for one boiler.

A quantity of assorted studs, bolts and nuts. Steel bars and plates of various sizes.

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*Not required for ships engaged on short voyages.

Section 30.

PERIODICAL SURVEYS.

For periodical surveys of the machinery and boilers *see* **Section 4, Periodical Survey Requirements.**

71, Fenchurch Street, London, E.C. 3

15th December, 1949.

REDUCTION GEARING INTENDED FOR MAIN PROPELLING MACHINERY AND FOR AUXILIARY ELECTRICAL GENERATING MACHINERY

INDEX

REDUCTION GEARING INTENDED FOR MAIN PROPELLING MACHINERY AND FOR AUXILIARY ELECTRICAL GENERATING MACHINERY

	Section.	Clause.	Page.
Main Propelling Machinery			
General	1	1	307
Alignment and bedding of gears ...	1	8	307
Balance of gear pinions and wheels	1	7	307
Dressing of the ends of the teeth	1	6	307
Gear loads	1	4	307
Plans, submission of	1	2	307
Primary pinion bearings	1	5	307
Materials—Pinions	2	1	307
Brinell tests	2	6	309
Forgings, manufacture of	2	3	308
„ mechanical properties of, after heat treatment ...	2	5	308
Heat treatment	2	4	308
Sulphur prints	2	7	309
Materials—Gear Wheel Rims			
Forgings, manufacture of	2	8	309
Heat treatment	2	9	309
Mechanical properties	2	10	309
Auxiliary Electrical Generating Machinery			
General	1	—	311
Alignment and bedding of gears ...	1	8	311
Balance of gear wheels	1	7	311
Dressing of the ends of the teeth	1	6	311
Gear loads	1	4	311
Plans, submission of	1	2	311
Primary pinion bearings ...	1	5	311
Welded construction	1	3	311
Materials	2	—	311

RULES FOR REDUCTION GEARING INTENDED FOR MAIN PROPELLING MACHINERY.

Section 1.

1. **General.** — The following requirements are applicable to all cases of reduction gearing for propelling purposes where more than 500 shaft horse-power is transmitted to the intermediate shaft.

2. Plans of gearing are to be submitted for approval together with the following particulars, viz. :—

Shaft horse-power and revolutions for each pinion,
Number of teeth in each gear,
Pitch circle diameters,
Helix angle,
Normal pitch of teeth,
Addendum,
Dedendum,
Type of tooth profile,
Face widths,
Pressure angle of teeth (normal or transverse).

In addition, arrangement plans are to be submitted for approval.

3. In the case of welded construction, full details of the welding and welding procedure are to be indicated. Gear wheels and gear cases of welded construction are to be suitably stress-relieved, particulars of which are to be submitted.

4. **Gear Loads.**—Gear loads for maximum designed shaft horse-power are not to exceed those given by the following formula, viz. :—

$$P = K \times d \times \frac{R}{R+1}$$

where P = load in lb. per inch of overall face width, without deduction for chamfering and tapering of tooth ends.

K = 80, except in the case of double reduction gears having the secondary pinion solid with the primary wheel, where K is to be taken as 67 for secondary gears only.

d = pitch circle diameter of the pinion in inches.

R = the gear ratio, pinion speed/gear wheel speed.

In cases where it is desired to use a higher value of P than that permitted by the foregoing formula, the Committee will be prepared to give consideration to the circumstances of any special case.

5. **Primary Pinion Bearings.**—Where the total axial length in inches over the gear face and gap is greater than

$$d \times (3{\cdot}5 - 0{\cdot}25 \sqrt{d})$$

where d is the pitch circle diameter of the pinion in inches.

a centre bearing is to be provided between the right and left-hand helices.

6. **Dressing of the Ends of the Teeth.**—The ends of the teeth are to be cut back at an angle of 45° to 60° to the pitch line and, in the case of pinions, are to be tapered on each tooth flank to an extent of at least 0·03 inch to nothing at a distance of $\frac{3}{8}$ inch measured parallel to the chamfered tooth end.

7. **Balance of Gear Pinions and Wheels.**—All primary pinions over 12 inches in diameter, complete with half claw couplings where fitted, are to be balanced dynamically.

All primary wheels, including those with secondary pinions, also main wheels, are to be balanced statically.

8. **Alignment and Bedding of Gears.**—The alignments of all wheel and pinion shafts, primary pinion drives from the turbines, main wheel and line shafting, also the bedding of the gears, are to be to the satisfaction of the Surveyors.

Section 2.

MATERIALS.

1. The materials used for pinions, pinion sleeves and gear wheel rims are to comply with the following requirements :—

(*a*) The steel is to be made by the Acid Open Hearth or Electric processes.

(*b*) Ingots are to be cast in chilled moulds with the larger diameter or cross sections uppermost and with efficient refractory feeder heads.

Pinions.

2. Pinions are to be made from nickel steel.

The chemical composition is to be as follows:—

Carbon ...	0·24	to	0·35	per cent.
Nickel ...	3·25	to	3·75	per cent.
Sulphur ...	not to exceed		·035	per cent.
Phosphorus	not to exceed		·035	per cent.

In cases where it is desired to use alternative alloys, full details of the chemical composition, physical properties and heat treatment are to be submitted for the consideration of the Committee.

3. **Manufacture of Forgings.**—The forgings are to be gradually and uniformly forged from ingots from which at least 5 per cent of the total weight of the ingot is removed from the bottom and not less than the following percentages of the total weight from the top of the ingot:—

Weight of Ingot.	Minimum top discard.
Below 2 tons ...	15%
2 to 5 tons	18%
Over 5 tons	25%

The sectional area of any part of the forging (as forged) is not to exceed:—

(1) One third of the sectional area of the ingot where the length at any diameter is greater than its diameter.

(2) Two thirds of the sectional area of the ingot where the length at any diameter is less than its diameter, *e.g.*, "a collar".

Sleeves are to be hollow forged or hollow rolled where practicable.

The forgings are to be made with sufficient material on the portion on which the teeth will be cut to allow not less than the following amounts being machined from surfaces of the finished forging before heat treatment, but leaving $\frac{1}{4}$ inch on all surfaces:—

(*a*) Large forgings for pinions 6 inches and over in diameter over the toothed portion when finished—one inch on diameters.

(*b*) Small forgings for pinions under 6 inches in diameter over the toothed portion when finished—$\frac{3}{4}$ inch on diameters.

4. **Heat Treatment.**—The forgings may be normalized and tempered or, alternatively, may be oil hardened and tempered.

5. **Mechanical Properties of Forgings.**

Longitudinal Tests.—One set of longitudinal test pieces, comprising tensile, bend and impact tests, is to be taken from one end of each pinion forging (or multiple forging), but if the length of the forging (or multiple forging) exceeds 48 inches, a set is to be taken from each end.

Transverse Tests.—Where the diameter of the body portion of the pinion or sleeve forging exceeds 8 inches, one set of transverse test pieces, comprising tensile, bend and impact tests, is to be taken from one end of the body portion or sleeve, but if the length of the body portion or sleeve exceeds 30 inches, a set is to be taken from each end.

In the case of single forgings having two body pieces and multiple forgings, where the sum of the lengths of the sleeves or body portions, including centre journals exceeds 30 inches and the diameter exceeds 8 inches, one set of transverse test pieces is to be taken from each of the two outer ends of the multiple of sleeves or the end body portions of the forging.

These transverse tests are additional to the longitudinal tests required to be taken from pinion forgings.

Where transverse tests are required from a pinion forging, but the difference in the diameters of the body portion and journal is such that it is not practicable to obtain transverse test pieces adjacent to the body portion, these should be taken from the ends of the forging.

Batch Testing.—Where a number of pinion forgings of the same dimensions are forged separately from the same cast and heat treated together in batches, and each forging does not exceed either a length of 48 inches or a weight of 3 cwts. as forged, the following test procedure may be adopted:—

Sufficient material for test purposes shall be left on 5 per cent. of the forgings constituting a heat treatment batch, the minimum number being two

forgings per batch. Sets of longitudinal and transverse tests taken from each of these forgings in accordance with the foregoing and including sulphur prints may be taken as representative of the batch. The results of these tests are to be confirmed by Brinell tests carried out on all forgings in accordance with Clause 6.

The forgings after heat treatment are to have the following mechanical properties, viz :—

Ultimate Tensile Strength (on standard test piece 2 inch × 0·564 inch diameter) to be not less than 40 tons per sq. inch, longitudinal and transverse.

Yield Point to be not less than 60 per cent. of the ultimate tensile strength, longitudinal and transverse.

Elongation to be not less than 23 per cent. in 2 inches longitudinal and 16 per cent. in 2 inches transverse.

Bend Test.—180° without fracture over $\frac{3}{4}$ inch radius, longitudinal and transverse. Dimensions of test piece $\frac{3}{4}$ inch × $\frac{3}{8}$ inch.

Impact Test.—Test specimens cut longitudinally 10 m.m. square with "V" notch 2 m.m. deep × 45°, with 0·25 m.m. radius at root, to give a value of not less than 35 ft. lb. in the case of oil-hardened and tempered steels and not less than 20 ft. lb. in the case of normalized and tempered steels.

Where the test pieces are cut transversely the foregoing values should be 20 and 15 ft. lb. respectively.

6. Brinell Tests.—Brinell tests are to be taken on all forgings, after machining to $\frac{1}{4}$ inch over finish machined diameter after heat treatment. The impressions are to be taken at each end of two diameters at right angles in three different positions over each toothed portion of the pinion. The forging will be considered sufficiently uniform if there is not more divergence than 30 in Brinell number between any two readings.

7. Sulphur Prints.—Sulphur prints are to be taken over the whole of the body portions of the forging on which teeth are to be cut, and in addition from each end of the body portions.

Gear Wheel Rims.

8. Manufacture of Forgings.—The rims are to be gradually and uniformly forged or rolled from ingots from which top and bottom discards, not less than required in the case of pinions, have been taken.

The forging for a single gear wheel rim is to be made sufficiently long to allow one set of transverse test pieces, comprising tensile and bend tests, to be taken from one end of the forging. In the case of multiple forgings, one set of transverse tests taken from each end of the forging will be sufficient, provided all the portions cut from the multiple forging are heat treated together.

Batch Testing.—Where a number of gear wheel rims of the same dimensions are forged from the same cast and heat treated together in batches, and do not exceed 3 cwts. each as forged, the following test procedure may be adopted :—

Sufficient material for test purposes shall be left on five per cent. of the forgings constituting a heat treatment batch, the minimum number being two forgings per batch. Sets of transverse tests from each of these forgings in accordance with the foregoing may be taken as representative of the batch.

9. Heat Treatment.—All rim forgings after completion are to be efficiently normalized.

10. Mechanical Properties.—The forgings after heat treatment are to have the following mechanical properties :—

(*a*) Ultimate Tensile Strength (on standard test piece 2 inch × 0·564 inch diameter cut circumferentially) to be between the limits of 31 to 35 tons per square inch, and the sum of the tensile breaking strength in tons per square inch and percentage elongation, measured on the standard test piece, is to be not less than 57.

(*b*) Bend Tests.—The bend test pieces are to withstand without fracture being bent cold through an angle of 180 degrees, the internal radius of the bend being not greater than $\frac{3}{8}$-inch.

(*c*) Dimensions of Bend Test Pieces.—The bend test pieces are to be machined to a rectangular section 1 inch wide by $\frac{3}{4}$-inch thick, with the edges rounded to a radius of $\frac{1}{16}$ of an inch. They are to be bent over the thinner section.

11. Gear wheel rims may be made of steel having a greater ultimate tensile strength than 35 tons per square inch, but in such cases full details of the mechanical properties should be submitted for approval.

12. In cases where separate rims are not used and the wheels are of solid forged construction, the mechanical properties of the material are to comply with **Section 2, clause 10.** Where, however, such wheels are of cast steel construction, full details of the chemical analysis, heat treatment and mechanical properties should be submitted for approval.

13. All forgings for pinions and wheel rims are to be sound and free from defects. Forgings may be rejected after the cutting of teeth, if defects are then revealed, notwithstanding acceptance during the earlier stages of manufacture.

14. Steels for parts used in the construction of gearing other than pinions and wheel rims shall comply with the requirements of the **Rules for the Testing of Ingot Steel Forgings**, or for **Boiler Quality Steel Plates**, as the case may be.

71, Fenchurch Street, London, E.C.3.

20th May, 1948.

RULES FOR REDUCTION GEARING INTENDED FOR AUXILIARY ELECTRICAL GENERATING MACHINERY.

Section 1.

1. **General.** — The following requirements are applicable to all cases of reduction gearing used in the generation of electric power for essential auxiliary services.

2. **Submission of Plans.**—The requirements of **Section 1, clause 2,** of the **Rules for Reduction Gearing intended for Main Propelling Machinery** are to be complied with where the gearing transmits 150 S.H.P. or over.

3. **Welded Construction.**—The requirements of **Section 1, clause 3,** of the **Rules for Reduction Gearing intended for Main Propelling Machinery** are to be complied with.

4. **Gear Loads.**—Gear loads are not to exceed those given by the following formula, **viz.** :—

$$P = K \times d \times \frac{R}{R + 1}$$

where P = load in lb. per inch of overall face width, including chamfering and tapering of tooth ends.

K = 90 at normal full load rating and 112·5 based on 25 per cent. overload.

d = pitch circle diameter of pinion in inches.

R = the gear ratio, pinion speed/gear wheel speed.

5. **Primary Pinion Bearings.**—The requirements of **Section 1, clause 5,** of the **Rules for Reduction Gearing intended for Main Propelling Machinery** are to be complied with.

6. **Dressing of the Ends of the Teeth.**—The ends of the teeth are to be cut back at an angle of 45° to 60° to the pitch line, and in the case of pinions, may be tapered on each tooth flank to an extent of 0·02 inch to nothing at a distance of $\frac{1}{4}$ inch measured parallel to the chamfered tooth end.

7. **Balance of Gear Wheels.**—Gear wheels are to be either statically or dynamically balanced.

8. **Alignment and Bedding of Gears.**—The alignments of wheel and pinion shafts, also the bedding of the gears, are to be to the satisfaction of the Surveyors.

Section 2.

MATERIALS.

The requirements of **Section 2** of the **Rules for Reduction Gearing intended for Main Propelling Machinery** are to be complied with, but where the gearing transmits less than 150 S.H.P. the material tests need not be witnessed by the Surveyors.

71, Fenchurch Street, London, E.C.3.
20th May, 1948.

WELDED PRESSURE VESSELS.

INDEX

WELDED PRESSURE VESSELS.

	Section.	Clause.	Page.
C			
Classification of Fusion Welded Pressure Vessels. Class 1 ...	1	4(*a*)	320
,, ,, Class 2 ...	1	4(*b*)	320
,, ,, Class 3 ...	1	4(*c*)	320
Definitions	1	1	315
Design	1	3	315
Dished plates without stays	1	3(*e*)	316
Figure 1. Typical acceptable methods of attaching flat end plates to cylindrical shells	1	—	318
,, 2. Typical acceptable methods of attaching branches, compensating rings and bosses	1	—	318
,, 3. Typical acceptable methods of securing flanges to branches which are directly attached to pressure vessels ...	1	—	319
,, 4. Typical acceptable methods of attaching dished ends to cylindrical shells ...	1	—	319
Quality of material	1	2	315
I			
Inspection of Fusion Welded Pressure Vessels	5	—	325
Electrodes	5	1	325
Fabrication	5	4	326
Heat treatment	5	2	325
Welding technique	5	3	325
L			
List of firms approved for Class 1 welding	—	—	328
R			
Requirements for Fusion Welding.			
Class 1	2	—	320
Alternative bend test	2	2(*i*)	321
Bend test	2	2(*h*)	321
Figure 5. Test plate	2	—	321
,, 6. Bend test	2	—	321
Figures 7, 8 & 9. Alternative bend test	2	—	322
Figure 10. Tensile test for joint	2	—	322
Heat treatment	2	3	323
Hydraulic test	2	4	323
Impact test	2	2(*j*)	322
Macro specimen	2	2(*l*)	322
Modification of requirements ...	2	5	323
Preliminary conditions and tests ...	2	1	320
Retests	2	2(*f*)	321
Routine tests for each welded pressure vessel	2	2(*a*)	320
Tensile test for joint	2	2(*k*)	322
Tensile test for weld metal	2	2(*g*)	321
X-ray examination	2	2(*m*)	322
Requirements for Fusion Welding.			
Class 2	3	—	323
Bend tests	3	2(*j*)	323
Heat treatment	3	3	324
Hydraulic test	3	4	324
Nicked bend test	3	2(*k*)	324
Preliminary conditions	3	1	323
Retests	3	2(*l*)	324
Routine tests for each welded pressure vessel	3	2(*a*)	323
Tensile tests	3	2(*h*)	323
Requirements for Fusion Welding.			
Class 3	4	—	324
Bend test	4	2(*h*)	324
Heat treatment	4	3	325
Hydraulic test	4	4	325
Nicked bend test	4	2(*j*)	324
Optional routine tests for each welded pressure vessel	4	2(*a*)	324
Preliminary conditions	4	1	324
Retests	4	2(*k*)	324
Tensile Test	4	2(*g*)	324
Requirements for Construction and Testing of Forge Welded Pressure Vessels. Class 1	6	—	326
Bend tests	6	3(*c*)	327
Classification of forge welded pressure vessels	6	1	326
Heat treatment	6	5	327
Heating	6	9	327
Hydraulic test	6	6	327
Plate thickness	6	7	327
Preliminary conditions and tests Class 1	6	2	326
Retests	6	3(*d*)	327
Routine tests for each welded pressure vessel Class 1	6	3(*a*)	327
Tensile test	5	3(*b*)	327
Weld thickness	6	8	327
T			
Table 1. Maximum permissible stresses in the longitudinal joints of fusion welded pressure vessels, for temperatures not exceeding 650° F.	—	—	316
,, **2.** Maximum permissible stresses in the longitudinal joints of forge welded pressure vessels, for temperatures not exceeding 650° F.	—	—	326

RULES FOR WELDED PRESSURE VESSELS.

Note:—The following rules relate to welded pressure vessels of thickness not less than $\frac{3}{16}$ inch and operating at temperatures not exceeding 650° F. Vessels intended for higher temperatures than 650° F. may be constructed in accordance with these rules, with the exception that the scantlings and routine tests required will be subject to special consideration when the plans are submitted for approval.

Section 1.

1. **Definitions.**—(*a*) The term "Fusion Weld" is, for the purposes of these rules, applicable to all welded joints made by the oxy-acetylene or the oxy-hydrogen process, the metal-arc process with covered electrodes, or other electric arc process in which the arc stream and the deposited weld metal are shielded from atmospheric contamination.

(*b*) The term "Forge Weld" is, for the purposes of these rules, applicable to joints made between plates which are welded together by means of hammering or rolling, and in which no added metal is included.

2. **Quality of Material.**—The material used in the construction of welded pressure vessels is to be in accordance with **Section 5** of the **Rules for the Quality and Testing of Materials.**

3. **Design.**—(*a*) In all cases, before construction is commenced, plans are to be submitted showing full details of the welding and giving particulars of the size and type of electrodes, also the ultimate tensile strength of the materials proposed to be used in the construction of the pressure vessel.

(*b*) In order to facilitate consideration when classifying pressure vessels, as per **Section 1, clause 4,** and especially in cases in which there may appear to be some doubt regarding the class under which a vessel may be considered, particulars of the service conditions for which the vessel is intended, should also be submitted.

(*c*) For the cylindrical shells of welded steel pressure vessels, the maximum working pressure to be allowed is to be calculated from the following formula :—

$$\mathbf{WP} = \frac{f\,(t-2)}{16 \times \mathbf{D}}$$

where $\mathbf{WP}$ = the working pressure in lb. per square inch.

f = the maximum permissible stress in the longitudinal joint in lb. per square inch, as given in Table 1 for Fusion Welded Pressure Vessels and Table 2 for Forge Welded Pressure Vessels.

t = the thickness of the shell plates in 32nds of an inch.

$\mathbf{D}$ = the internal diameter of the cylindrical shell in inches.

TABLE 1.

MAXIMUM PERMISSIBLE STRESSES IN THE LONGITUDINAL JOINTS OF FUSION WELDED PRESSURE VESSELS, FOR TEMPERATURES NOT EXCEEDING 650° F.

Conditions in respect of Routine Tests and Heat Treatment.		Maximum Permissible Stress 'f' to be used in Formula given in Section 1, clause 3 (c).					
		Minimum Tensile Strength of Plate :— 26 tons per sq. in.			Minimum Tensile Strength of Plate :— 28 tons per sq. in.		
		Class 1. lb. per sq. in.	Class 2. lb per sq. in.	Class 3. lb. per sq. in.	Class 1. lb. per sq. in.	Class 2. lb. per sq. in.	Class 3. lb. per sq.in.
Vessels made by approved manufacturers only and subject to routine tests prescribed in Section 2, clause 2, and including complete X-ray examination and heat treatment.	Unfired vessels.	12,900	—	—	13,900	—	—
	Fired vessels.	12,200	—	—	13,100	—	—
Subject to routine tests prescribed in Section 3, clause 2, and including heat treatment.		—	A. 11,500	—	—	A. 12,400	—
Subject to routine tests prescribed in Section 3, clause 2, but not including heat treatment.		—	B. 10,800	—	—	B. 11,600	—
Subject to routine tests prescribed in Section 4, clause 2, and including heat treatment.		—	—	A. 10,000	—	—	A. 10,800
Subject to routine tests prescribed in Section 4, clause 2, but not including heat treatment.		—	—	B. 9,300	—	—	B. 10,000
Subject to hydraulic test only.		—	—	C. 8,600	—	—	C. 9,300
Double fillet lap joint for longitudinal shell seams, for shell thickness not exceeding $\frac{3}{8}$ in. Subject to hydraulic test only.		—	—	D. 7,900	—	—	D. 8,500

NOTE: Where the minimum tensile strength of the plate material is other than 26 or 28 tons per sq. in., but not more than 35 tons per sq. in., the maximum permissible stress should be proportional to the above.

(d) Where tube plates form portions of cylindrical drums, their thickness in way of the tube holes is to be calculated by the following formula :—

$$t = \frac{WP \times C \times D}{S \times J} + 4$$

$$\text{or } WP = \frac{(t - 4)\, S \times J}{C \times D}$$

where **D** is the internal diameter of the drum in inches

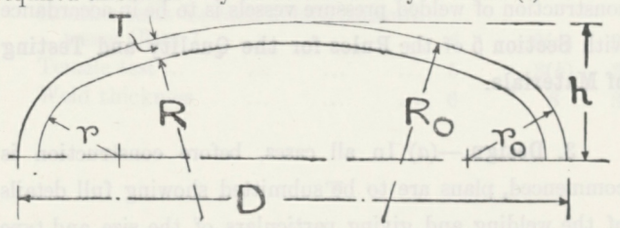
t is the thickness of tube plates, in 32nds of an inch.

S is the minimum tensile strength of the plate forming the drum, in tons per square inch.

J is the percentage strength of the plate through the tube holes, viz. :— $\frac{p - d}{p} \times 100$ where p is the pitch of the tubes in inches, on lines parallel with the axis of the drum and d is the diameter of the tube holes in inches,

C = 3.

(e) **Dished Plates without Stays.**—For ends of boiler drums and receivers, crowns of vertical boilers and other similar plates intended for Class 1 pressure vessels and dished to partial spherical form, subject to pressure on the concave side, but not exposed to flame, and having no unreinforced opening greater than four times the thickness of the plate, the required thickness of plate is to be determined by formula (a) or (b). For end plates of similar type intended for Class 2 or Class 3 Pressure Vessels, the required thickness may be determined by formula (c).



(a) $$WP = \frac{4726 \times S \times h}{D^2} \left\{ \frac{\frac{r}{R} + 0{\cdot}05}{\frac{r}{R} + 0{\cdot}15} \right\} \times (T - 0{\cdot}03)$$

(b) $$WP = \frac{480 \times S\,(T - 0{\cdot}03)}{R}$$

(c) $$WP = \frac{576 \times S \times T}{R}$$ for Class 2 and Class 3 ONLY.

where **T** = thickness of the end in inches after dishing but in no case to be less than the thickness of a seamless unpierced shell of the same diameter and material.

WP = working pressure in lb. per square inch.

S = minimum tensile strength of the material in tons per square inch.

D = outside diameter of drum end in inches.

R = inside radius of curvature of end in inches, which is not to exceed **D**.

r = inside corner radius in inches.

h = external height of dishing in inches measured from the centre of the inside corner radius and may be determined as follows :—

$$h = R_0 - \sqrt{\left(R_0 - \frac{D}{2}\right)\left(R_0 + \frac{D}{2} - 2r_0\right)}.$$

where R_0 = outside radius of curvature of the end in inches.

r_0 = outside corner radius in inches.

The inside corner radius "r" is not to be less than four times the thickness of the end plate and in no case less than 2·5 inches.

(*f*) Proposals to make dished end plates of semi-elliptic form will be considered provided full details are submitted before the work is commenced.

(*g*) Where the end plates are dished to partial spherical form, subject to pressure on the convex side and not fitted with stays, the following formula is to be used :—

$$WP = \frac{C \times T \times S}{R}$$

where **T** = the thickness of the end plate in inches.

R = the radius of the convex surface of the end plate in inches, which is not to exceed the diameter of the shell.

S = minimum tensile strength of the material in tons per square inch.

C = 310 for Class 1 Pressure Vessels when **T** does not exceed $\frac{9}{16}$ inch,

= 340 for Class 1 Pressure Vessels when **T** exceeds $\frac{9}{16}$ inch,

= 370 for Classes 2 and 3 Pressure Vessels when **T** does not exceed $\frac{9}{16}$ inch,

= 410 for Classes 2 and 3 Pressure Vessels when **T** exceeds $\frac{9}{16}$ inch.

(*h*) Where the end is provided with a flanged manhole the thickness of the end in inches obtained by the foregoing formulæ, is to be increased by $\frac{1}{8}$ inch, and the depth of the manhole flange, measured in inches from the outer surface at the minor axis is not to be less than

$$F = \sqrt{T_1 \times W}$$

where T_1 = the required thickness of the end plate in inches.

W = the minor axis of the manhole in inches.

(*j*) Where the end is provided with large openings for branches, mountings or unflanged manholes, the thickness of the end as determined by the foregoing formulæ shall be increased by $\frac{1}{8}$ inch and adequate compensation shall be provided, at least equivalent to the cross sectional area obtained by multiplying the diameter or major axis of the opening cut in the end plate by the thickness required for an equivalent unpierced end.

(*k*) Where the end is provided with small openings greater than four times the thickness of the end plate, local compensation is to be provided.

(*l*) For unstayed flat end plates welded to cylindrical shells either by forge welding or by one of the fusion welded methods shown in **Fig. 1.**

$$WP = \frac{C \times (t_1 - 1)^2}{D^2}$$

where **WP** = the working pressure in lb. per square inch.

t_1 = the thickness of the end plate in 32nds of an inch.

D = the internal diameter in inches.

C = 72·5 when end plate is exposed to flame.

= 100 when end plate is not exposed to flame.

(*m*) Where a flat plate is flanged to stiffen it at a manhole or sighthole, the total depth of the flange measured in inches from the outer surface is to be at least equal to $\sqrt{t \times w}$, where t is the thickness of the plate in inches and w is the minor axis of the hole in inches.

(*n*) Manholes in cylindrical shells are to have their shorter axes arranged longitudinally. Where the cylindrical shell is cut for a manhole, compensation is to be provided in accordance with **clause 3** (*o*).

(*o*) Compensation is to be provided for all openings in shell plates if the diameters of such openings exceed $2\frac{1}{2}$ times the thickness of the shell plus $2\frac{3}{4}$ inches.

The total area of compensation to be provided is not to be less than the sectional area of the plate cut out to form the opening multiplied by the ratio :—

$$\frac{\text{Permissible stress in welded joint in lb. per sq. in.}}{560 \times \text{min}^{\text{m}}\text{. tensile strength of shell plate in tons per sq. in.}}$$

The sectional area cut out is to be based on the thickness of a seamless shell and measured on the centre line of the opening parallel with the longitudinal axis of the shell, and the area of compensation provided is to be

measured in the same plane as the sectional area cut out, and may include the sectional area of the welds by which the compensating plate or branch piece may be attached.

In cases where branch pieces are welded to the shell or end plate, the maximum height of the branch body to be reckoned as compensating for the sectional area cut-out is to be obtained thus :—

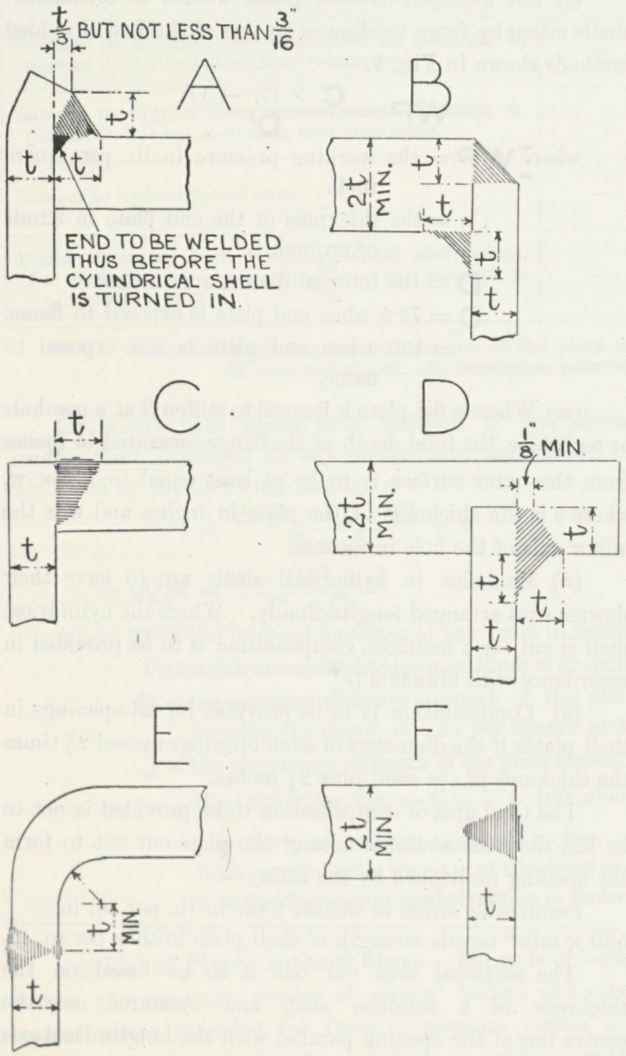
$$H = 1{\cdot}2\sqrt{D \times T}$$

where **H** = the height in inches measured from the inside surface of the shell or end plate,

D = the diameter or longitudinal axis, in inches of the opening cut in the plate,

T = the thickness in inches of the shell or end plate.

FIG. 1. TYPICAL ACCEPTABLE METHODS OF ATTACHING FLAT END PLATES TO CYLINDRICAL SHELLS.



NOTE :—The proportions indicated for the welds are minima only

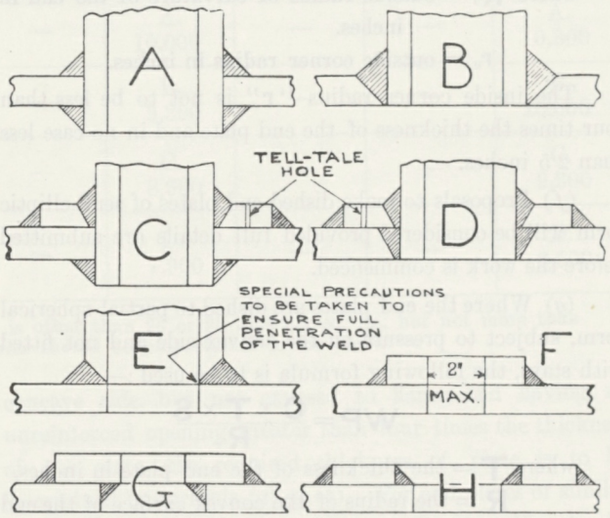
If the height of the branch obtained by the above formula, in conjunction with its thickness is inadequate to compensate for the sectional area cut-out, additional compensation is to be provided.

(*p*) All welded compensating plates, branch pieces and bosses may be secured by one of the methods shown in **Fig. 2.**

Compensating plates attached to the outside of a vessel as in Fig. 2 (C) and (D) are to be provided with a tell-tale hole not greater than $\frac{3}{8}$" diameter. The tell-tale hole is to be left open to the atmosphere.

In the case of compensating plates attached to the inside of a vessel the tell-tale hole is to be drilled in the shell.

FIG. 2. TYPICAL ACCEPTABLE METHODS OF ATTACHING BRANCHES, COMPENSATING RINGS AND BOSSES.



NOTE :—Type (E) should be used for the attachment of heavy branches to relatively thick shells.

Flanges may be attached to branch pieces by any of the methods shown in **Fig. 3.**

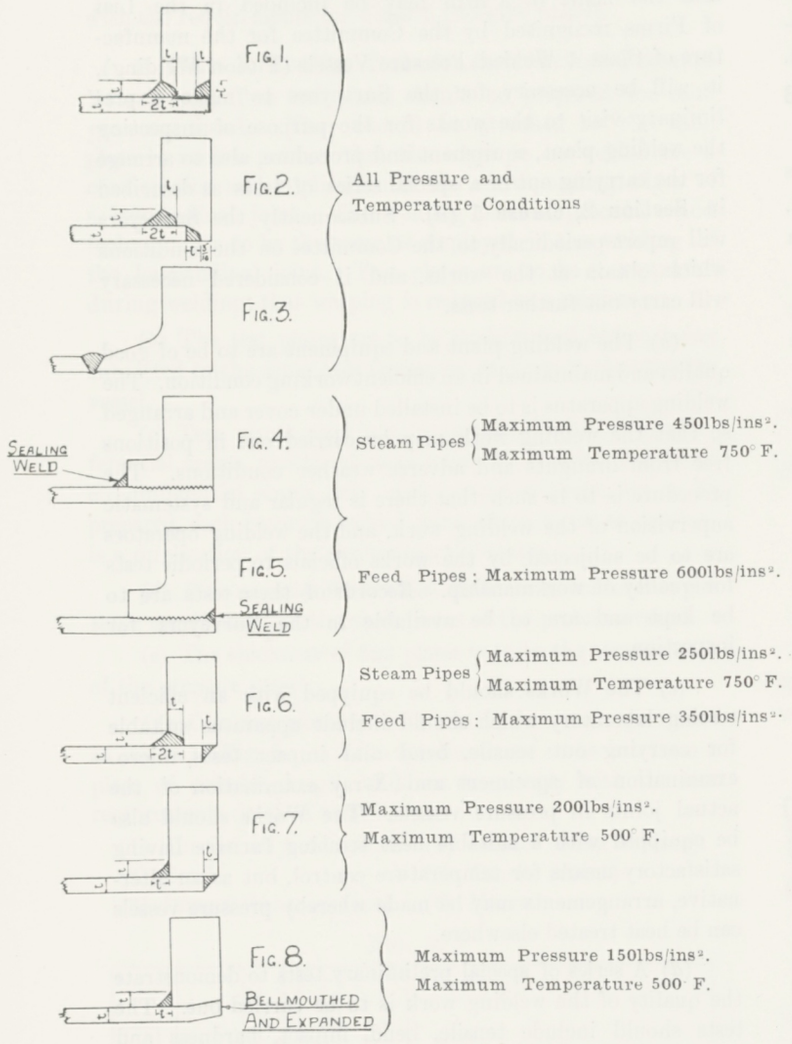
Alternative methods will be accepted if considered to be of equivalent strength.

Where flanges are secured by screwing, the branch and flange are to be screwed with a vanishing thread, and the diameter of the screwed portion of the branch over the thread must not be less than the outside diameter of the unscrewed branch.

After the flange has been screwed hard home the branch is to be expanded into the flange and may be provided with a sealing weld. (See type (E) Fig. 3.)

The vanishing thread on a branch is to be not less than three pitches in length and the diameter at the root of the thread is to increase uniformly from the standard root diameter to the diameter at the top of the thread. This may be produced by suitably grinding the dies, and the flange should be tapered out to the same formation.

FIG. 3. TYPICAL ACCEPTABLE METHODS OF SECURING FLANGES TO BRANCHES WHICH ARE DIRECTLY ATTACHED TO PRESSURE VESSELS.



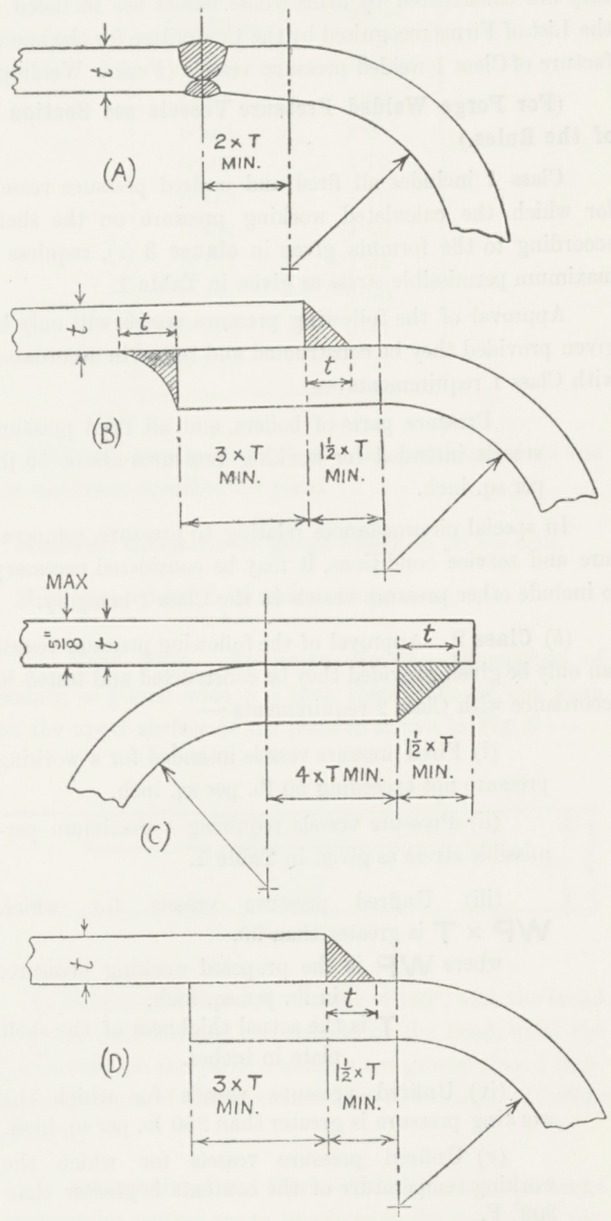
NOTE:—The proportions indicated for the welds are minima only.

(*q*) Where a dished end plate, concave to the pressure is fixed by a fillet welded lap joint, the width of the overlap, measured between the edges of the end plate and shell plate, is not to be less than three times the thickness of the end plate. The outside fillet weld is to be clear of the knuckle of the flange.

Dished end plates convex to the pressure may be permitted, provided the thickness of the shell plate does not exceed $\frac{5}{8}$ inch, and the width of flange is not less than four times the thickness of the end plate.

Permissible forms of fusion welded circumferential joints for dished end plates are shown in **Fig. 4.**

FIG. 4. TYPICAL ACCEPTABLE METHODS OF ATTACHING DISHED ENDS TO CYLINDRICAL SHELLS.



T = thickness of dished end plate.

NOTE:—Types (B) (C) and (D) are not acceptable for Class 1 pressure vessels. Type (D) should only be used for Class 3 pressure vessels in which *t* does not exceed ½ inch.

(*r*) Where a dished end plate is fixed by a butt joint and the thickness of an end plate exceeds that of the shell, the end plate shall be gradually reduced to the thickness of the shell plate for a length not less than twice the thickness of the end plate, measured from the centre line of the weld.

4. Classification of Fusion Welded Pressure Vessels.—(*a*) **Class 1.** Pressure vessels made in accordance with the requirements of this class will be accepted only if they are constructed by firms whose names are included in the List of Firms recognised by the Committee for the manufacture of Class 1 welded pressure vessels (Fusion Welding).

(For Forge Welded Pressure Vessels see Section 6 of the Rules.)

Class 1 includes all fired and unfired pressure vessels for which the calculated working pressure on the shell, according to the formula given in **clause 3** (*c*), requires a maximum permissible stress as given in **Table 1.**

Approval of the following pressure vessels will only be given provided they be constructed and tested in accordance with Class 1 requirements:—

Pressure parts of boilers, and all fired pressure vessels intended for working pressures above 50 lb. per sq. inch.

In special circumstances relating to pressure, temperature and service conditions, it may be considered necessary to include other pressure vessels in the Class 1 category.

(*b*) **Class 2.** Approval of the following pressure vessels can only be given provided they be constructed and tested in accordance with Class 2 requirements:—

(i) Fired pressure vessels intended for a working pressure not exceeding 50 lb. per sq. inch.

(ii) Pressure vessels requiring a maximum permissible stress as given in **Table 1.**

(iii) Unfired pressure vessels for which $WP \times T$ is greater than 90.

where WP is the proposed working pressure, in lb. per sq. inch,

T is the actual thickness of the shell plate in inches.

(iv) Unfired pressure vessels for which the working pressure is greater than 250 lb. per sq. inch.

(v) Unfired pressure vessels for which the working temperature of the contents is greater than 300° F.

(vi) Unfired pressure vessels of shell thickness greater than $\frac{5}{8}$ inch.

(*c*) **Class 3.** This class includes all unfired pressure vessels not included in Classes 1 and 2 for which the calculated working pressure on the shell, according to the formula given in **clause 3** (*c*) requires a maximum permissible stress as given in **Table 1.**

Section 2.

Class 1. Requirements for Fusion Welding.

1. Preliminary Conditions and Tests.—(*a*) In order that the name of a firm may be included in the List of Firms recognised by the Committee for the manufacture of Class 1 Welded Pressure Vessels (Fusion Welding), it will be necessary for the Surveyors to make a preliminary visit to the works for the purpose of inspecting the welding plant, equipment and procedure, also to arrange for the carrying out of a special series of tests as described in **Section 2, clause 1** (*d*). Subsequently the Surveyors will report periodically to the Committee on the conditions which obtain at the works, and if considered necessary will carry out further tests.

(*b*) The welding plant and equipment are to be of good quality and maintained in an efficient working condition. The welding apparatus is to be installed under cover and arranged so that the welding work may be carried out in positions free from draughts and adverse weather conditions. The procedure is to be such that there is regular and systematic supervision of the welding work, and the welding operators are to be subjected by the works officials to periodic tests for quality of workmanship. Records of these tests are to be kept and are to be available to the Surveyors for inspection.

(*c*) The Works should be equipped with an efficient testing laboratory which should include apparatus suitable for carrying out tensile, bend and impact tests, micro-examination of specimens and X-ray examination of the actual joints in pressure vessels. The Works should also be equipped with a suitable heat treating furnace having satisfactory means for temperature control, but as an alternative, arrangements may be made whereby pressure vessels can be heat treated elsewhere.

(*d*) A series of special preliminary tests to demonstrate the quality of the welding work is to be carried out. The tests should include tensile, bend, impact, hardness and fatigue tests on specimens which should be prepared in a similar manner to that used in the making of longitudinal joints in pressure vessels. The Surveyors are to select portions of the test plates from which photomicrographs, at 100 and 300 magnifications, are to be prepared representing the weld centre, fusion zone and plate. The test plates from which the specimens are taken, are to be X-rayed.

(*e*) A chemical analysis, including determination of oxygen and nitrogen content, is to be made of weld metal deposited in a sample joint in which the parent plate material is similar to that normally used in the manufacture of welded pressure vessels. A chemical analysis of the plates forming the sample joint should also be made, alternatively a guaranteed analysis obtained from the steelmakers will be accepted.

(*f*) A full size welded pressure vessel is to be manufactured under survey, and is to comply in every respect with the requirements for Class 1 pressure vessels.

2. Class 1. Routine Tests for each Welded Pressure Vessel.—(*a*) Two test plates should be prepared for each pressure vessel. They should be attached to the shell plate in such a manner that the edges to be welded are a continuation and duplication of the corresponding edges of a longitudinal joint. The welding process, procedure and technique are to be the same as employed in the welding of the longitudinal joint. Test plates are to be so supported during welding, that warping is reduced to a minimum.

(*b*) The test plates are to be straightened before being subjected to the same heat treatment as given to the pressure vessel.

(*c*) Test plates need not be prepared for the circumferential seams, except in cases where a pressure vessel has circumferential seams only, when two test plates are to be prepared, each having a welded joint which, so far as possible, is a duplication of the circumferential seams.

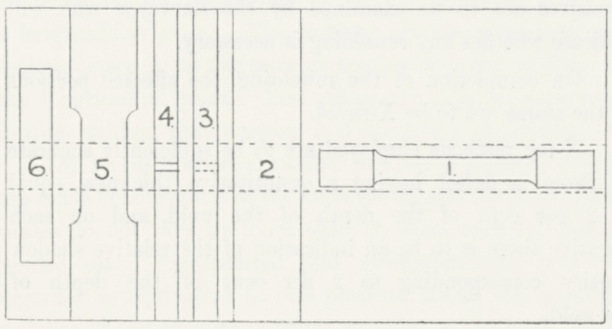
(*d*) The material for the test plates is to conform to the same specification as the shell plates of the pressure vessel.

(*e*) The thickness of test plates is to be the same as that of the pressure vessel.

(*f*) One test plate is to be cut up into test specimens as shown in **Fig. 5.** All the specimens are to be cut from a plate of suitable length and are to comply with the test requirements detailed as follows :—

(1) Tensile, all weld metal.
(2) Bend.
(3) Impact (inner surface).
(4) Impact (outer surface).
(5) Tensile (Joint).
(6) Macro.

FIG. 5.



Retests.—If any of the tests fail, two retests are to be made on specimens cut from the second test plate.

All retests are to comply fully with the test requirements.

(*g*) **Tensile Test for Weld Metal. Specimen No. 1.**—

Diameter of Test Piece. in.	Gauge Length. in.
0·798	2·82
0·564	2·0
0·505	1·79
0·479	1·70
0·452	1·60
0·437	1·55
0·424	1·50
0·399	1·41
0·357	1·26

Ultimate tensile strength of weld metal to be not less than minimum specified for plate.

Minimum elongation on gauge length = 20 per cent.

Minimum reduction of area = 35 per cent.

(*h*) **Bend Test. Specimen No. 2.**—Dimensions of specimen = $\frac{3}{4}$ inch wide × $\frac{3}{8}$ inch thick. To be cut flush with the upper surface of the plate as shown in **Fig. 6** :—

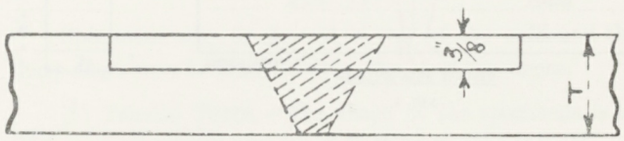


FIG. 6.

To be bent cold through an angle of 180°, with the broad side of the weld forming the outside of the bend, until the distance between the parallel sides is not greater than $\frac{3}{8}$ inch. The sharp edges of the specimen may be rounded off before bending.

(*i*) **Alternative Bend Test.**—Two bend test specimens of rectangular section are to be cut from the test plate, one to be bent with the outer surface of the weld in tension, and the other with the inner surface in tension.

The specimens are to be cut transversely to the weld and are to have a width equal to $1\frac{1}{2}$ times the thickness of the specimen. The edges may be rounded off to a radius not exceeding 10 per cent. of the thickness of the specimen.

In plate thicknesses not exceeding $1\frac{1}{4}$ inches, the thickness of the specimens should be equal to the thickness of the test plate. Where the plate thickness exceeds $1\frac{1}{4}$ inches, the specimens should, in all cases, have a thickness of $1\frac{1}{4}$ inches, and width of $1\frac{7}{8}$ inches. These should be prepared by discarding metal from the surfaces of the specimens which will be in compression when the test is applied. (*See* **Figs. 7** and **8.**)

Where the thickness of the plate permits, the bend specimens may be prepared as shown in **Fig. 9.**

For each specimen the weld reinforcement should be removed by buffing or machining so that the outer and inner surfaces of the weld are flush with the surface of the plate.

Each specimen is to be bent cold without fracture through an angle of 180°, over a former having diameter equal to three times the thickness of the specimen. The distance between supports should be not more than 5·2 times the thickness of the specimen.

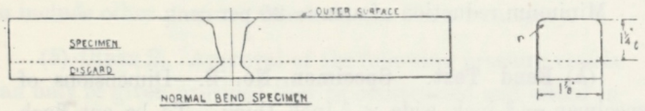


FIG. 7.

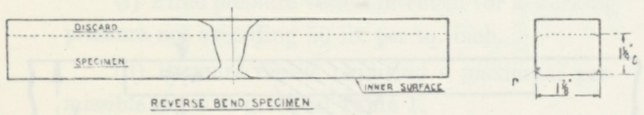


FIG. 8.

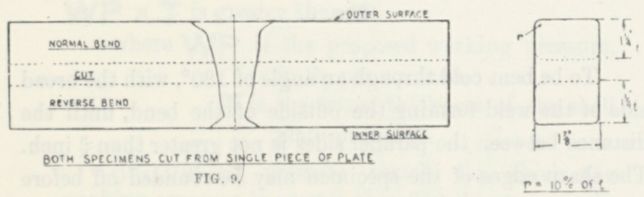


FIG. 9.

(*j*) **Impact Test. Specimens Nos. 3 and 4.**—Dimensions 0·394 inch square. One specimen to have a milled V notch cut in the centre of the outer surface of the weld and the other at the centre of the inner surface of the weld Minimum IZOD value = 25 ft. lb.

(*k*) **Tensile Test for Joint. Specimen No. 5.**

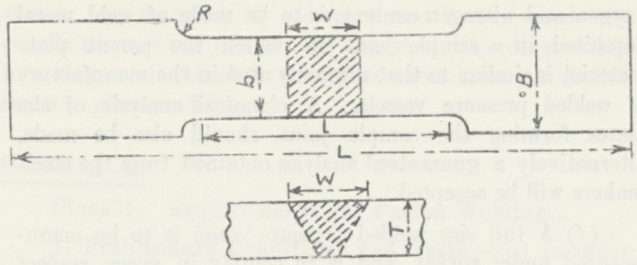


FIG. 10.

Dimensions (Fig. 10):—

When T is less than 1 inch:—

L = 10 inches.
l = w + $\frac{1}{2}$ inch. R = $\frac{3}{16}$ inch.
B = $1\frac{1}{4}$ inches.
b = $\frac{7}{8}$ inch.

When T is greater than 1 inch:—

L = 12 inches.
l = w + $\frac{1}{2}$ inch. R = $\frac{1}{4}$ inch.
B = $1\frac{1}{2}$ inches.
b = 1 inch.

An equivalent form of test piece to the above may be accepted.

The weld is to be machined flush with plates on both sides.

Ultimate tensile strength to be not less than minimum specified for plate.

(*l*) **Macro Specimen. Specimen No. 6.**—The specimen is to be etched across the full section of the weld, and examined by the Surveyor.

(*m*) **X-ray Examination.**—X-ray photographs are to be taken of the entire length of each welded seam, both longitudinal and circumferential. The surface of the weld shall be dressed smooth by grinding, chipping and grinding, machining or other suitable means, to the satisfaction of the Surveyor, for the purpose of radiography. The photographs are to be marked in such a way that the corresponding portion of the welded seam can readily be identified. The negatives are to be examined by the Surveyor who will indicate whether any rewelding is necessary.

On completion of the rewelding, the affected portions of the seams are to be X-rayed.

X-ray methods employed are to be sufficiently accurate to reveal a defect having a quantitative thickness equal to 2 per cent of the depth of the weld, and on each negative there is to be an indication of the relative shadow density corresponding to 2 per cent of the depth of the weld.

3. **Class 1. Heat Treatment.** — Each pressure vessel is to be efficiently heat treated on completion of the welding and before the hydraulic test is carried out.

The heat treatment given to any pressure vessel may be either :—

(1) Normalizing, in which the pressure vessel is heated uniformly to a temperature of 920° C. and allowed to cool slowly in still air.

(2) Stress Relieving, in which the pressure vessel is heated uniformly to a temperature between 600° C. and 650° C., and allowed to cool slowly in still air.

4. **Class 1. Hydraulic Test.**—For pressure vessels intended for working pressures up to 100 lb. per square inch, the hydraulic test pressure is to be twice the working pressure. Where working pressures exceed 100 lb. per square inch, the hydraulic test pressure is to be $1\frac{1}{2}$ times the working pressure plus 50 lb. per square inch.

Whilst under this test the pressure vessel is to be well hammered on both sides of, and close to, the welded seams.

5. **Modification of Requirements.**—In the case of firms of large experience some modification may be permitted in regard to the requirements of **Section 2, clause 1** and to the requirements relating to Routine Tests for Class 1 Welded Pressure Vessels.

Section 3.

Class 2. Requirements for Fusion Welding.

1. **Preliminary Conditions.**—The welding of Class 2 Pressure Vessels is to be done only by firms who satisfy the Committee that their works are properly equipped for the welding of pressure vessels.

The welding plant is to be installed under cover and is to be maintained in an efficient working condition and adequate supervision of the welding work is to be provided.

2. **Class 2. Routine Tests for each Welded Pressure Vessel.**—(*a*) Two test plates should be prepared for each pressure vessel. They should be attached to the shell plate in such a manner that the edges to be welded are a continuation and duplication of the corresponding edges of a longitudinal joint. The welding process, procedure and technique are to be the same as employed in the welding of the longitudinal joint. Test plates are to be so supported during welding that warping is reduced to a minimum.

(*b*) In cases where a number of Class 2 pressure vessels are made concurrently at the same works, and the plate thicknesses do not vary by more than $\frac{3}{16}$ inch, each 120 feet of welded seam, longitudinal plus circumferential, may be regarded as equivalent to one pressure vessel, the required number of test specimens being provided accordingly.

In these cases the thickness of the test plates is to be equal to that of the thickest shell plate used in the construction of the pressure vessels.

(*c*) The test plates are to be straightened before being subjected to the same heat treatment as given to the pressure vessel.

(*d*) Test plates need not be prepared for the circumferential seams, except in cases where a pressure vessel has circumferential seams only, when two test plates are to be prepared each having a welded joint which, so far as possible, is a duplication of the circumferential seams.

(*e*) The material for the test plates is to conform to the same specification as the shell plates of the pressure vessel.

(*f*) The thickness of test plates is to be the same as that of the pressure vessel.

(*g*) One test plate is to be cut up into test specimens as shown in **Fig. 11.** All the specimens are to comply with the test requirements detailed as follows :—

		TENSILE.
		BEND.
		TENSILE.
		BEND.
		NICKED BEND.

FIG. 11.

Specimens may be dressed in way of the weld and the sharp edges may be removed from the bend specimens.

(*h*) **Tensile Tests.**—The shape of the specimens is to conform to the requirements of **Section 2, clause 2** (*k*).

The ultimate tensile strength of the joint is to be not less than the minimum specified for the plate.

(*j*) **Bend Tests.**—The width of the bend specimens is to be not less than $1\frac{1}{2}$ times the thickness, and the mid portion of the specimens is to coincide with the centre line of the weld. One specimen is to be bent with the outer surface of the weld in tension, and the other specimen is to be bent with the outer surface of the weld in compression.

In both cases the specimens are to be bent without fracture through 180° round a former, the diameter of which is not greater than 3 times the thickness of the specimen.

(*k*) **Nicked Bend Test.**—The specimen is to have a slot cut into each side of the weld. The specimen is then to be broken in the weld and the fracture is to reveal a sound homogeneous weld, substantially free from slag inclusions porosity and coarse crystallinity.

(*l*) **Retests.**—If any of the tests fail, two retests are to be made on specimens cut from the second test plate. All retests are to comply fully with the test requirements.

3. **Class 2. Heat Treatment.**—Where heat treatment is required to be carried out in respect of any pressure vessel (*see* Table 1), the requirements of **Section 2, clause 3,** are to be complied with.

Pressure vessels for which the ratio of inside diameter in inches to the cube of the shell thickness in inches is less than 100 are to be efficiently heat treated.

4. **Class 2. Hydraulic Test.**—For pressure vessels intended for working pressures up to 100 lb. per square inch, the hydraulic test pressure is to be twice the working pressure. Where working pressures exceed 100 lb. per square inch, the hydraulic test pressure is to be $1\frac{1}{2}$ times the working pressure plus 50 lb. per square inch.

Whilst under this test the pressure vessel is to be well hammered on both sides of, and close to, the welded seams.

Section 4.

Class 3. Requirements for Fusion Welding.

1. **Preliminary Conditions.**—The welding of Class 3 Pressure Vessels is to be done only by firms who satisfy the Committee that their works are properly equipped for the welding of pressure vessels.

The welding plant is to be installed under cover and is to be maintained in efficient working condition and adequate supervision of the welding work is to be provided.

2. **Class 3. Optional Routine Tests for each Welded Pressure Vessel.**—(*a*) Pressure vessels which comply with the following test requirements, including heat treatment, will be allowed the maximum permissible stress given in **Table 1** for Class 3 pressure vessels.

The permissible stresses are reduced when heat treatment and routine tests are omitted. (*See* **Table 1.**)

In the case of pressure vessels having a shell plate thickness not exceeding $\frac{3}{8}$ inch, double fillet lap joints for the longitudinal seams will be permitted in conjunction with a maximum permissible stress as given in **Table 1.** In this case heat treatment and routine tests may be omitted.

(*b*) Two test plates should be prepared for each pressure vessel. They should be attached to the shell plate in such a manner that the edges to be welded are a continuation and duplication of the corresponding edges of a longitudinal joint. The welding process, procedure and technique are to be the same as employed in the welding of the longitudinal joint. Test plates are to be so supported during welding that warping is reduced to a minimum.

(*c*) The test plates are to be straightened before being subjected to the same heat treatment as given to the pressure vessel.

(*d*) The material for the test plates is to conform to the same specification as the shell plates of the pressure vessel.

(*e*) The thickness of test plates is to be the same as that of the pressure vessel.

(*f*) One test plate is to be cut up to provide one tensile, one bend and one nicked bend specimen.

(*g*) **Tensile Test.**—The shape of the specimen is to conform to the requirements of **Section 2, clause 2** (*k*). The ultimate tensile strength of the joint is to be not less than 95 per cent. of the minimum specified for the plate.

(*h*) **Bend Test.**—The width of the bend specimen is to be not less than $1\frac{1}{2}$ times the thickness, and the centre of the specimen is to coincide with the centre line of the weld. The specimen is to be bent with the outer surface of the weld in tension, through an angle of 160° without fracture round a former the diameter of which is not greater than 3 times the thickness of the specimen.

(*j*) **Nicked Bend Test.**—The specimen is to have a slot cut into each side of the weld. The specimen is then to be broken in the weld and the fracture is to reveal a sound homogeneous weld, substantially free from slag inclusions porosity and coarse crystallinity.

(*k*) **Retests.**—If any of the tests fail, two retests are to be made on specimens cut from the second test plate. All retests are to comply fully with the test requirements.

(*l*) In cases where a number of Class 3 pressure vessels are made concurrently at the same works, and the plate thicknesses do not vary by more than $\frac{3}{16}$ inch, each 120 feet of welded seam, longitudinal plus circumferential, may be regarded as equivalent to one pressure vessel, the required number of test specimens being provided accordingly.

In these cases, the thickness of the test plates is to be equal to that of the thickest shell plate used in the construction of the pressure vessels.

(*m*) Test plates are not required in the case of pressure vessels having circumferential welded seams only.

3. **Class 3. Heat Treatment.**—Class 3. Pressure Vessels may be required to be heat treated, depending upon the details of design and the service for which the pressure vessels are intended.

Where heat treatment is required to be carried out on any pressure vessel, the requirements of **Section 2, clause 3,** are to be complied with.

4. **Class 3. Hydraulic Test.**—For pressure vessels intended for working pressures up to 100 lb. per square inch, the hydraulic test pressure is to be twice the working pressure. Where working pressures exceed 100 lb. per square inch, the hydraulic test pressure is to be $1\frac{1}{2}$ times the working pressure plus 50 lb. per square inch.

Whilst under this test the pressure vessel is to be well hammered on both sides of, and close to, the welded seams.

Section 5.

Inspection of Fusion Welded Pressure Vessels.

NOTE :—The following requirements are applicable to all classes of fusion welded pressure vessels.

1. **Electrodes.**—(*a*) In the case of pressure vessels welded by the electric metallic arc process, the electrodes are to be of a type conforming to the terms of the definition for fusion welds given in **Section 1, clause 1** (*a*).

(*b*) Electrodes intended for use in the construction of pressure vessels are to be stored in a dry place. In order to ensure that the quality of the electrodes is being consistently maintained they are to be subjected to a regular system of periodic testing and inspection. Where routine tests are frequently carried out in respect of pressure vessels made in the normal course of production, such tests may be regarded as meeting the requirements of this clause.

(*c*) In cases in which it is proposed to use electrodes of larger size than $\frac{3}{8}$ inch diameter, full particulars are to be submitted for consideration.

2. **Heat Treatment.**—(*a*) The heat treatment of pressure vessels is to be carried out by placing the pressure vessels in a properly constructed furnace having satisfactory means of temperature control.

(*b*) Where pressure vessels are of such dimensions that the whole length cannot be accommodated in the furnace at one time, the pressure vessels may be heated in sections provided sufficient overlap is allowed to ensure the heat treatment of the entire length of the longitudinal seam.

(*c*) Test plates should be heat treated in the same furnace and at the same time as the pressure vessels which they represent. In special cases, however, it may be permissible to heat treat the test plates separately from the pressure vessels provided the Surveyor is satisfied with the means adopted to ensure that the following factors will be the same for the pressure vessels as for their respective test plates :—

Rate of heating.
Maximum temperature.
Time held at maximum temperature.
Conditions of cooling.

(*d*) Where a number of test plates are heated together in a furnace, care is to be taken to ensure that each plate is uniformly exposed to the heat of the furnace.

(*e*) In cases where it is proposed to adopt special methods of heat treatment full particulars are to be submitted for consideration. In such cases it may be necessary to carry out tests to show the effect of the proposed heat treatment.

3. **Welding Technique.**—(*a*) Welding may be carried out by hand or by machine, and the current used in electric metallic arc welding may be direct or alternating. In welding branch pieces, pads and compensating rings, more than one run of weld metal is to be deposited. Longitudinal and circumferential seams may be reinforced by additional runs of weld metal.

(*b*) The outer surfaces of the welds may be flush with the surfaces of the plates joined, but no objection will be raised if the total thickness at the centre of the weld is greater than the thickness of the plates, provided the change of section is gradual and there is no undercutting at the sides of the weld.

(*c*) Each run of weld metal is to be thoroughly cleaned and free from slag before the next run is deposited.

(*d*) In all Class 1 pressure vessels, the longitudinal and circumferential seams are to be welded from both sides of the plate. In the case of Class 2 and Class 3 pressure vessels which are too small to permit welding from the inside, special care should be taken to ensure full penetration of the first run of weld metal. In such cases it is recommended that a backing strip be provided on the underside of the joint. In order to satisfy himself regarding the penetration, the Surveyor may, if he considers it necessary, request that a sample joint be welded and cut open for his inspection.

(*e*) The welding of pressure vessels is to be carried out in the downhand horizontal position. In the case of circumferential seams means are to be adopted to ensure compliance with this requirement.

(*f*) In cases where it is proposed to adopt fusion welding processes in which it may not be possible to comply fully with the foregoing requirements regarding technique, full particulars are to be submitted for consideration.

4. **Fabrication.**—(*a*) Before welding, the assembly is to be examined. The shape and size of the joints are to be in accordance with the approved design. The butting edges of the plates forming the longitudinal and circumferential seams are to be in line within a limit of 10 per cent. of the plate thickness, but in no case exceeding $\frac{1}{8}$ inch for longitudinal joints and $\frac{3}{16}$ inch for circumferential joints.

(*b*) The attachment of branches should be examined before and after welding.

(*c*) During fabrication, the Surveyor is to be provided with opportunities for seeing the actual deposition of weld metal. The joints are to be examined at various stages during construction.

(*d*) On completion of the welding, the seams are to be thoroughly examined before being dressed or machined. Parts showing evidence of blow-holes, slag inclusions, unsatisfactory penetration, porosity, or any other defect, are to be cut out and rewelded, and excessive undercutting made good.

(*e*) Each pressure vessel is to be calibrated for distortion. The calibration is to be made after the heat treatment has been carried out. The drum or shell is to be circular at any section within a limit of one per cent. of the designed internal diameter based on the difference between the maximum and minimum diameters of any section. Any departure from circularity is to be gradual and there is to be no local flat in way of the welded seam.

Section 6.

REQUIREMENTS FOR CONSTRUCTION AND TESTING OF FORGE WELDED PRESSURE VESSELS.

1. **Classification of Forge Welded Pressure Vessels.**—(*a*) **Class 1.** Pressure vessels made in accordance with the requirements of this class will be accepted only if they are constructed by firms whose names are included in the List of Firms recognised by the Committee for the manufacture of Class 1 welded pressure vessels (Forge Welding).

Class 1 includes all fired and unfired pressure vessels for which the calculated working pressure on the shell, according to the formula given in **Section 1, clause 3** (*c*), requires a maximum permissible stress as given in **Table 2.**

Approval of the following pressure vessels will only be given provided they be constructed and tested in accordance with Class 1 requirements :—

> Pressure parts of boilers, and all fired pressure vessels intended for working pressures above 50 lb. per sq. inch.

In special circumstances relating to pressure, temperature and service conditions, it may be considered necessary to include other pressure vessels in the Class 1 category.

(*b*) For Forge Welded Pressure Vessels not included in Class 1 the working pressure of the shell is to be calculated from the formula shown in **Section 1, clause 3** (*c*), the maximum permissible stress being as given in **Table 2.**

TABLE 2.

MAXIMUM PERMISSIBLE STRESSES IN THE LONGITUDINAL JOINTS OF FORGE WELDED PRESSURE VESSELS, FOR TEMPERATURES NOT EXCEEDING 650° F.

		Minimum tensile strength 24 Tons per sq. in.	Minimum tensile strength 26 Tons per sq. in.
CLASS 1.	Unfired vessels.	11,200 lb. per sq. in.	12,200 lb. per sq. in.
	Fired vessels.	10,600 lb. per sq. in.	11,500 lb. per sq. in.
All other Classes.	Where shell thickness is $\frac{5}{8}$ in. and above.	9,900 lb. per sq. in.	10,800 lb. per sq. in.
	Where shell thickness is less than $\frac{5}{8}$ in.	9,200 lb. per sq. in.	10,000 lb. per sq. in.

2. **Class 1. Preliminary Conditions and Tests.**—(*a*) In order that the name of a firm may be included in the List of Firms recognised by the Committee for the manufacture of Class 1 Welded Pressure Vessels (Forge Welding), it will be necessary for the Surveyors to make a preliminary visit to the Works for the purpose of inspecting the welding plant, equipment and procedure also to arrange for the carrying out of a special series of tests as described in **Section 6, clause 1** (*d*). Subsequently the Surveyors will report periodically to the Committee on the conditions which obtain at the Works, and if considered necessary will carry out further tests.

(*b*) The welding plant and equipment are to be of good quality and maintained in efficient working condition. The

welding plant is to be installed under cover and arranged so that the welding work may be carried out in positions free from draughts and adverse weather conditions. The procedure is to be such that there is regular and systematic supervision of the welding work.

(*c*) The Works should be equipped with an efficient testing laboratory which should include apparatus suitable for carrying out tensile, bend and impact tests, and micro examination. The Works should also be equipped with a suitable heat treating furnace having satisfactory means for temperature control, but as an alternative, arrangements may be made whereby pressure vessels can be heat treated elsewhere.

(*d*) A series of special preliminary tests to demonstrate the quality of the welding work is to be carried out. The tests should include tensile, bend, impact, hardness and fatigue tests on specimens which should be prepared in a similar manner to that used in the making of longitudinal joints in pressure vessels. The Surveyors are to select portions of the test plates from which photomicrographs, at 100 and 300 magnifications, are to be prepared representing the weld centre, and the plate remote from the weld.

(*e*) A full size pressure vessel is to be manufactured under survey, and is to comply in every respect with the requirements for Class 1 Forge Welded Vessels.

(*f*) In the case of firms of large experience some modification may be permitted in regard to the requirements of **Section 6, clause 2** (*d*) above, provided satisfactory evidence is produced of successful results obtained by the firm's welding methods, over an appreciable period.

3. **Class 1. Routine Tests for each Welded Pressure Vessel.**—(*a*) The shell plates are to be left long enough to accommodate the following test specimens:—

(1) Two Tensile specimens. } With provision
(2) Four Bend specimens. } for retests.

(*b*) **Tensile Test.**—The tensile specimens are to conform to the Standard Test Piece A, the mid portion of the test specimens coinciding with the weld.

The ultimate tensile strength of both test pieces is to be not less than 95 per cent. of the minimum specified for the plate material. The elongation is to be not less than 18 per cent on a gauge length of 8 inches.

(*c*) **Bend Tests.**—The width of the bend specimens is to be not less than $1\frac{1}{2}$ times the thickness, and the centre of the specimens is to coincide with the centre line of the weld. Two specimens are to be bent in such a manner that the outer surface of the weld is in tension, and two specimens are to be bent with the outer surface of the weld in compression.

In both cases the specimens are to be bent without fracture through 180° round a former, the diameter of which is not greater than 3 times the thickness of the specimen.

NOTE:—Some modification of the requirements contained in paragraphs (*a*), (*b*) and (*c*) may be permitted in circumstances such as are indicated in **clause 2** (*f*).

(*d*) **Retests.**—If any of the tests fail, two retests are to be made, both of which are to comply fully with the test requirements.

(*e*) In the case of pressure vessels having circumferential joints only, no test pieces need be provided unless the internal diameter of the pressure vessel exceeds 4 ft. 6 ins., when a representative welded joint is to be made and cut up to provide the specimens detailed above.

4. In the case of forge welded pressure vessels other than those included in Class 1 routine tests are not required in respect of longitudinal joints, but where the internal diameter of a pressure vessel exceeds 4 ft. 6 ins. the manufacturer is to produce authoritative evidence of test results demonstrating that efficient circumferential welds of the proposed dimensions can be made consistently.

5. **Heat Treatment.**—All forge welded pressure vessels are to be efficiently normalized in accordance with the requirements of **Section 2, clause 3** (1).

6. **Hydraulic Test.**—Pressure vessels are to be subjected to a hydraulic test pressure of twice the working pressure. Whilst under this test the pressure vessel is to be well hammered on both sides of, and close to, the welded seams.

7. **Plate Thickness.**—In the case of all pressure vessels the thickness of the shell plate is to be not less than $\frac{1}{4}$ inch.

8. **Weld Thickness.**—On completion of the welding the thickness at and adjacent to the weld is to be not less than the required thickness of the shell plate as determined from the formulæ for the Working Pressure given in **Section 1, clauses 3** (*c*) and **3** (*d*).

9. **Heating.**—The heating of plates for welding is to be carried out by means of a process which will provide a flame which will not be of an oxidizing character and will not tend to introduce impurities into the steel. Provision is to be made for careful control of the welding heat.

APPENDIX.

List of Firms recognised by the Committee, for the manufacture of Class 1 Welded Pressure Vessels, as at 31st December, 1949.

Fusion Welding:—

Babcock & Wilcox, Ld., Renfrew, Scotland.

John Thompson (Wolverhampton), Ld., Wolverhampton, England.

Sulzer Bros., Winterthur, Switzerland.

Brown-Boveri, Ld., Baden, Switzerland.

The Foster Wheeler Corporation, Carteret, N.J., U.S.A.

The Sun Shipbuilding & Dry Dock Co., Chester, Pa. U.S.A.

The Babcock & Wilcox Company, Barberton, Ohio, U.S.A.

G. A. Harvey & Co. (London), Ld., London.

Combustion Engineering Co., Inc., New York, U.S.A. (Works at Chattanooga, Tennessee).

A. O. Smith Corporation, Milwaukee, Wisconsin, U.S.A.

Ruston & Hornsby, Ld., Lincoln, England.

Dominion Bridge Co., Ld., Lachine, Quebec, Canada.

Daniel Adamson & Co., Ld., Dukinfield, Cheshire, England.

Henry Balfour & Co., Ld., Leven, Fife, Scotland.

Aktiebolaget Lindholmens Varv., Gothenburg, Sweden.

Vancouver Iron Works, Ld., Vancouver, B.C., Canada.

Farrar & Trefts, Inc., Buffalo, New York, U.S.A.

Marshall & Anderson, Ld., Motherwell, Lanarkshire, Scotland. (Broomside Works).

Canadian Vickers, Ld., Montreal, Canada.

Avesta Jernverks Aktiebolag, Avesta, Sweden.

John Inglis & Co., Ld., Toronto, Canada.

Canadian General Electric Co., Ld. (Canadian Allis-Chalmers, Ld.), Davenport Works, Toronto, Canada.

Ashmore, Benson, Pease & Co., Ld., Parkfield Works, Stockton-on-Tees, England.

Cochran & Co., Annan, Ld., Annan, Scotland.

Heilman Boiler Works, Allentown, Pa., U.S.A.

John Brown & Co., Ld., Clydebank, Scotland.

South Durham Steel & Iron Co. Ltd., Stockton-on-Tees, England.

N.V. Werkspoor, Amsterdam, Holland.

Horseley Bridge & Thomas Piggott Ld., Tipton, Staffs

Gebr. Stork & Co. N.V., Hengelo, Holland.

Whessoe Ld., Darlington.

Ansaldo Stabilimento Meccanico, Genoa, Italy.

Thompsons (Castlemaine) Ld., Melbourne, Australia.

Yarrow & Co., Ld., Scotstoun, Glasgow.

Combustion Engineering Co., Inc., New York, U.S.A. (Works at St. Louis).

Head, Wrightson & Co., Ld., Thornaby-on-Tees.

Foster Wheeler Ld., St. Catharines, Ontario.

Bernard Smith (Pty.) Ld., Sydney, N.S.W.

The M.W. Kellogg Co., Jersey City 3, N.J., U.S.A.

Vitkovice Steel Works, N.C. Ostrava 10, Czechoslovakia.

Motherwell Bridge & Engineering Co., Ld., Glasgow.

De Rotterdamsche Droogdok Maatschappij, N.V., Holland.

A/S. Burmeister & Wain, Copenhagen, Denmark.

Robey & Co., Ld., Globe Works, Lincoln.

Bethlehem Steel Co., Bethlehem, Pa., U.S.A.

Huttenwerk Huckingen A.G., Duisburg, Germany.

Cockatoo Docks & Engineering Co., Pty., Ld., Sydney, N.S.W.

Helsingor Skibsværft & Maskinbyggeri, Elsinore, Denmark.

Harland & Wolff, Ld., Belfast.

Forge Welding:—

John Thompson (Wolverhampton) Ld., Wolverhampton, England.

71, Fenchurch Street, London, E.C.3.

20th May, 1948.

PETROL AND PARAFFIN ENGINES

INDEX

PETROL AND PARAFFIN ENGINES

	Section.	Clause.	Page.
Accessibility	2	3	333
Bronze liners on shaft	3	10	335
Bronze propellers	3	13	335
Commutators	2	7	333
Compressed air receivers	2	11	333
Couplings	3	12	335
Crank webs, dimensions of	3	4	334
Electric ignition	2	7	333
Engines driving electric generators ...	2	6	333
Governor	2	5	333
High tensile steel shafting	3	1(*b*)	334
Hydraulic testing of cylinder liners, water jackets and water passages ...	2	9,10	333
Lamps used for ignition or vaporizing ...	2	18	333
Reversing gear and clutch	2	4	333
Shafts, diameters of			
„ crank	3	2	334
„ flywheel	3	6	334
„ intermediate	3	5	334
„ screw	3	9	335
„ thrust	3	7	335
„ tube	3	8	335
Shafts of special high tensile steel ...	3	1(*b*)	334
Spare gear	4	—	335
Stern bush	3	11	335
Surveys, periodical	—	—	23
Test of machinery	2	12	333

RULES FOR THE CONSTRUCTION AND SURVEY OF PETROL AND PARAFFIN ENGINES.

Section 1.

GENERAL.

In ships propelled by Petrol or Paraffin Engines, the Rules as regards Machinery are the same as those relating to steam engines so far as regards the testing of material used in their construction and the fitting of sea connections, discharge pipes, shafting, stern tubes and propellers. Where it is proposed to depart from the requirements of the Rules, the Committee will be prepared to give consideration to the circumstances of any special case.

Section 2.

CONSTRUCTION.

1. In order to facilitate the inspection, plans in triplicate of the following items are to be submitted for consideration before the work is commenced :—

(*a*) Crank, thrust, intermediate and screw shafting.

(*b*) Clutch, reversing and reduction gear.

NOTE :—*See* **Rules for Pumping and Piping** for other plans to be submitted.

2. The following points are to be observed in connection with the design of the engines.

3. The shaft bearings, connecting rod brasses, the valve gear, the inlet and exhaust valves are to be easily accessible.

4. The reversing gear and clutch are to be strongly constructed and easily accessible for examination and adjustment.

5. In engines of above 60 B.H.P. which are not reversible and which are manœuvred by clutch, a governor or other arrangement is to be fitted to prevent racing of the engine when de-clutched.

6. Engines intended for driving electric generators are to comply with the requirements of the **Rules for Electrical Equipment, Section 2, clauses 1, 13, 14, 17, 18,** and **20,** where these are applicable.

7. If the ignition is electric, either by magneto or by coil and accumulator, all electric leads are to be well insulated and suitably protected from mechanical injury. The leads are not to be placed where they may be brought into contact with oil or petrol.

The commutator is to be enclosed, and the sparking coils are not to be placed where they can be exposed to explosive vapour.

8. In paraffin engines where lamps are used for ignition or for vaporizing, these lamps are to be fixed by some suitable bracket, and the flame enclosed when in use.

9. Where the cylinder liners are made of hard close grained cast iron of plain cylindrical form, accurately turned on the outside as well as bored on the inside, so that their soundness can be ascertained by inspection, they need not be hydraulically tested by internal pressure. If, however, they are made of complicated form, the question of testing is to be submitted.

10. The water jackets of the cylinders, and the water passages of the cylinder covers and pistons are to be tested by hydraulic pressure to 30 lb. per square inch and are to be perfectly tight at that pressure.

11. If compressed air receivers are fitted, they are to comply with the requirements of **Section 6 (Rules for Heavy Oil Engines).**

12. The machinery is to be tried under full working conditions, the report stating the approximate speed of ship, the number of revolutions of the engines at full power, both ahead and astern, and the lowest number of revolutions of the engines which can be maintained for manœuvring purposes.

For pumping arrangements, drainage, cooling water and lubricating oil systems *see* **Rules for Pumping and Piping.**

For fuel tanks, pipes and fittings *see* **Section 20, Rules for Steel Ships** and **Rules for Pumping and Piping.**

Section 3.

RULES FOR DETERMINING SIZES OF SHAFTS.

1.—(*a*) The crank, intermediate and other shafts, if of ordinary mild steel having a tensile breaking strength of 28–32 tons per square inch, are to be of not less diameters than those given by the following formulæ. The formulæ do not, however, take into consideration the possibility of

severe torsional vibration stresses arising in the shafting and where the circumstances are such as to indicate that critical speeds will occur within the range of working speeds, the sizes of shafting are to be specially submitted for the consideration of the Committee.

(*b*) Where shafts are proposed to be made of special high tensile steel, their sizes should be submitted for consideration.

2. **Crank Shafts.**—The diameter of the crank shaft of the main engines is not to be less than that given by the following formula :—

$$\left.\begin{array}{l}\text{Diameter of crank shaft, in inches or millimetres}\end{array}\right\} = \sqrt[3]{D^2 \times (A\,S + B\,L)}$$

where **D** = diameter of cylinder, in inches or millimetres,

S = length of stroke, in inches or millimetres,

L = span of bearings adjacent to a crank, measured from inner edge to inner edge, in inches or millimetres.

The values of **A** and **B** given in Table I. apply to engines in which there are bearings adjacent to each side of each crank. If there are two cranks between consecutive bearings the same Rules will apply, but **L** will be the span of bearings from inner edge to inner edge adjacent to the two cranks.

TABLE I.

4 Cycle Single Acting Engines.	2 Cycle Single Acting Engines.	For Smooth Water Service Values of		For Open Sea Service Values of	
		A	B	A	B
1,2,3 or 4 Cyls.	1 or 2 Cyls.	·025	·022	·028	·024
6 „	3 „	·031	·021	·034	·023
8 „	4 „	·035	·020	·039	·022
12 „	6 „	·048	·017	·053	·019

3. For engines of the aforementioned types driving auxiliary machinery, the diameters of the crank shafts may be 5 per cent. less than given by the foregoing formula applying to main engines for open sea service.

4. **Crank Webs.**—In solid forged shafts the breadth of the webs should not be less than 1·33, and the thickness not less than ·56 times the diameter of the shaft as found by the foregoing formula or if these proportions are departed from, the webs are to be of equivalent strength.

5. **Intermediate Shafts.**—The diameter of the intermediate shafts is not to be less than that given by the following formula :—

$$\left.\begin{array}{l}\text{Diameter of intermediate shaft, in inches or millimetres ...}\end{array}\right\} = C\sqrt[3]{D^2 \times S}$$

where **D** = diameter of cylinder, in inches or millimetres,

S = length of stroke, in inches or millimetres,

C is a coefficient found from Table II. by interpolation from the values found for **A** :—

$$A = \frac{D^2 \times S}{W \times d^2 \times R^2}$$

where **D** = diameter of cylinder, in inches,

S = length of stroke, in inches,

d = diameter of fly wheel, in feet,

R = revolutions of engines per minute,

W = total weight of fly wheel, in tons.

TABLE II.

FOR SMOOTH WATER SERVICE.				
4 Cycle Single Acting Engines.	2 Cycle Single Acting Engines.	Values of the Coefficient C where		
		A=·0025	A=·0050	A=·0100
2 Cyl.	1 Cyl.	·240	·250	·256
3 „	—	·255	·264	·270
4 „	2 „	·272	·277	·282
6 „	3 „	·298	·301	·304
8 „	4 „	·322	·324	·325
12 „	6 „	·363	·364	·365
FOR OPEN SEA SERVICE.				
4 Cycle Single Acting Engines.	2 Cycle Single Acting Engines.	Values of the Coefficient C where		
		A=·0025	A=·0050	A=·0100
2 Cyl.	1 Cyl.	·252	·262	·269
3 „	—	·269	·276	·283
4 „	2 „	·286	·291	·296
6 „	3 „	·313	·316	·319
8 „	4 „	·338	·340	·341
12 „	6 „	·382	·382	·383

6. If a separate fly wheel shaft is fitted its diameter is to be at least equal to that of the crank shaft.

7. **Thrust Shafts.**—The diameter at the collars of thrust shafts transmitting torque is not to be less than 1·05 times that required for the intermediate shaft. Thrust shafts may be tapered down outside the collars to the diameter required for the intermediate shaft.

8. **Tube Shafts** (shafts passing through stern tubes but not carrying the screw propellers).—The diameter of the tube shaft is not to be less than 1·05 times that required for the intermediate shaft, and any part of the shaft within the tube which may be exposed to sea water is not to be less than 1·075 times that required for the intermediate shaft.

9. **Screw Shafts** (shafts carrying the screw propellers) —(*a*) The diameter of the screw shaft is not to be less than that given by the following formula :—

$$\text{Diameter of screw shaft, in inches or millimetres} = d + \frac{P}{C}$$

where d is the diameter required for the intermediate shaft, in inches or millimetres,

P is the diameter of the propeller, in inches or millimetres,

C = 144 when the shaft is fitted with a continuous liner, or

C = 100 when the shaft is not fitted with a continuous liner.

(*b*) Screw shafts which run in stern tubes may have the end forward of the stern gland tapered down to a diameter, at the coupling flange, of 1·05 times d.

10. **Bronze Liners on Shafts.**—(*a*) The thickness of liners fitted on screw shafts, or on tube shafts, in way of the bushes, is not to be less than that given by the following formulæ :—

$$t = \frac{d + 9{\cdot}25}{32} \quad \text{or} \quad t_m = \frac{d + 235}{32}$$

where t is the thickness of the liner, in inches,

t_m is the thickness of the liner, in millimetres,

d is the diameter required for the screw or tube shaft under the liner, in inches or millimetres.

(*b*) The thickness of a continuous liner between the bushes is not to be less than $\frac{3}{4}t$ or $\frac{3}{4}t_m$.

(*c*) Continuous liners should be cast in one piece or, if made of two or more lengths, the junctions of the separate pieces are to be made by fusion through the whole thickness of the liner.

(*d*) Liners are to be carefully shrunk on, or forced on to the shafts by hydraulic pressure. Pins are not to be used to secure the liners.

(*e*) If the liner does not fit tightly between the bearings in the stern tube, the space between the shaft and the liner is to be charged or forced with a plastic material insoluble in water and non-corrosive.

(*f*) Effective means are to be provided for preventing water from having access to the shaft at the part between the after end of the liner and the propeller boss.

11. **Stern Bush.**—The length of the bearing in the stern bush next to and supporting the propeller is not to be less than 4 times the diameter required for the screw shaft under the liner.

12. **Couplings.**—(*a*) The diameter of the coupling bolts at the joining faces of the couplings is not to be less than that given by the following formula :—

$$\left.\begin{array}{l}\text{Diameter of coupling bolts,}\\ \text{in inches or millimetres ...}\end{array}\right\} = \sqrt{\frac{d^3}{3{\cdot}5 \times n \times r}}$$

where d is the diameter required for the intermediate shafts, in inches or millimetres,

n is the number of bolts in the coupling,

r is the radius of the pitch circle of the bolts, in inches or millimetres

(*b*) The thickness of the coupling flanges at the pitch circle of the bolt holes is not to be less than the diameter of the coupling bolts, at the face of the coupling. The thickness of the screw shaft coupling flange is not to be less than ·25 of the diameter required for the intermediate shaft.

(*c*) The radius of curvature at the fillet where the flange starts from the shaft should not be less than ·125 times the diameter of the shaft adjacent to the flange.

(*d*) Where couplings are separate from the shafts, provision is to be made to resist the astern pull.

13. **Bronze Propellers.**—Where bronze is used for propellers or propeller blades, it is to comply with the requirements of **Section 11** of the **Rules for Quality and Testing of Materials.**

Section 4.

Spare Gear.—The items of spare gear to be carried for petrol and paraffin engines employed for essential services are to be equivalent to those required for heavy oil engines intended for similar services.

Section 5.

PERIODICAL SURVEYS.

For periodical surveys of the machinery, *see* **Section 4, Periodical Survey Requirements, "Petrol, Paraffin, and Heavy Oil Engines."**

71, Fenchurch Street, London, E.C.3.

15th December, 1949.

HEAVY OIL ENGINES

AND THEIR AUXILIARIES.

INDEX

HEAVY OIL ENGINES AND THEIR AUXILIARIES.

	Section.	Clause.	Page.
Air compressors and coolers	5	5	351
„ „ (number of auxiliaries required)	5	6	351
„ „ (small auxiliary) ...	5	7	351
Air receivers	6	—	351
„ „ annealing	6	7	352
„ „ capacity	6	1	351
„ „ draining arrangements ...	6	12	352
„ „ fitting of safety valve ...	6	11	352
„ „ hydraulic testing	6	8, 9	352
„ „ internal examination ...	6	10	352
„ „ material	6	2	351
„ „ riveted receivers	6	4	352
„ „ seamless receivers	6	5	352
„ „ thickness of welded or seamless shell	6	6	352
„ „ welded receivers	6	3	351
Auxiliary engines	2	1	339
Construction under special survey ...	2	—	339
Couplings (single acting engines) ...	3	12	341
„ (double acting engines) ...	4	12	350
Crank webs, dimensions of (single acting engines) ...	3	3, 4	340
„ „ (double acting engines) ...	4	3, 4	347
Cylinder safety valves	5	4	351
Electrically driven auxiliaries ...	7	3	353
Engines driving electric generators ...	5	10	351
Exhaust pipes and silencer	5	3	351

	Section	Clause.	Page.
High tensile steel shafting	3	1(*b*)	339
	4	1(*b*)	347
Hydraulic testing of cylinder liners, water jackets and water passages	5	1, 2	350
Novel constructions, submission of ...	2	6	339
Oil fuel pipes, tanks and fittings ...	7	1	353
Plans, submission of	2	3	339
Propellers, bronze (single acting engines)	3	13	341
„ „ (double „ „)	4	13	350
Screw shafts, periodical examination of	3	4	23
Shafts, bronze liners on (single acting engines) ...	3	10	341
„ „ „ (double acting engines) ...	4	10	350
Shafts, diameters of			
„ crank (single acting engines) ...	3	2	340
„ „ (double „ „) ...	4	2	347
„ flywheel (single acting engines) ...	3	6	341
„ „ (double „ „) ...	4	6	350
„ intermediate (single acting engines)	3	5	340
„ „ (double „ „)	4	5	347
„ screw (single acting engines) ...	3	9	341
„ „ (double „ „) ...	4	9	350
„ thrust (single acting engines) ...	3	7	341
„ „ (double „ „) ...	4	7	350
Spare gear	8	—	353
Stern bush (single acting engines) ...	3	11	341
„ (double „ „) ..	4	11	350
Surveys, periodical	3	—	22
Survey, records of	3	5	24
	2	2	339
Ventilation of engine room	7	2	353

RULES FOR THE CONSTRUCTION AND SURVEY OF HEAVY OIL ENGINES AND THEIR AUXILIARIES.

Section 1.

GENERAL.

In ships propelled by heavy oil engines, the Rules as regards Machinery are the same as those relating to steam engines, so far as regards the testing of material used in their construction and the fitting of sea connections, discharge pipes, shafting, stern tubes, and propellers.

Section 2.

CONSTRUCTION.

1. In ships built under Special Survey and fitted with heavy oil engines, the main and auxiliary engines, air receivers, boilers, steering engines, all pumps, evaporators and feed water heaters and pressure filters intended for essential services, and domestic boilers intended for working pressures exceeding 50 lb. per square inch or having heating surfaces greater than 50 square feet are also to be constructed under Special Survey.

2. In cases of heavy oil engines being built under Special Survey, the distinguishing mark ✠ will be noted in the Register Book in Red, thus :—✠LMC or ✠NE.

3. In order to facilitate the inspection, plans in triplicate of the following items are to be submitted for consideration before the work is commenced :

(*a*) Crank, thrust, intermediate and screw shafting.
(*b*) Clutch, reversing and reduction gear.
(*c*) Air receivers.
(*d*) Boilers.
(*e*) Evaporators, feed water heaters and feed water pressure filters.

NOTE :—*See* **Rules for Pumping and Piping** for other plans to be submitted.

The plans of machinery space piping are to be diagrammatic.

4. The Surveyors are to examine the materials and workmanship from the commencement of the work until the final test of the machinery under full power working conditions; any defects are to be pointed out as early as possible.

5. Where it is proposed to depart from the requirements of these Rules, the Committee will be prepared to give consideration to the circumstances of any special case.

6. Any novelty in the construction of the machinery is to be reported to the Committee and submitted for approval.

Section 3.

SINGLE ACTING ENGINES.

RULES FOR DETERMINING SIZES OF SHAFTS.

1. (*a*) The crank, intermediate and other shafts, if of ordinary mild steel having a tensile breaking strength of 28–32 tons per square inch are to be of not less diameters than those given by the following formulæ.

The formulæ do not, however, take into consideration the possibility of severe torsional vibration stresses arising in the shafting.

Calculations of the torsional vibration characteristics for the dynamic system formed by the engine, shafting and propeller, also gearing or generators, where these are interposed, are to be submitted for consideration, together with plans of all shafting. These calculations should include frequency tables for the one and two node natural frequencies, also three node where necessary, and particulars of the firing order. In drawing up frequency tables, the single amplitude of swing should be taken as one radian at the first mass at the end of the engine remote from the driving end. The vector summations are to be given for the relative angular displacements of the working cranks for all orders of vibration occurring at speeds less than 30 per cent. above the normal running speed.

Similar calculations are to be submitted for heavy oil engines of 100 B.H.P. or more driving auxiliary machinery used for essential services at sea.

In certain cases the Committee may consider it necessary for torsiograph readings to be taken from the machinery after fitting on board, for the purpose of verifying that serious critical speeds do not occur within the range of working speeds.

(*b*) Where shafts are proposed to be made of special high tensile steel, their sizes should be submitted for consideration.

2. **Crank Shafts.**—The diameter of the crank shaft of the main engines is not to be less than that given by the following formula :—

$$\left.\begin{array}{l}\text{Diameter of crank}\\ \text{shaft, in inches}\\ \text{or millimetres}\end{array}\right\} = \sqrt[3]{D^2 \times (AS + BL)}$$

where **D** = diameter of cylinder, in inches or millimetres,

S = length of stroke, in inches or millimetres,

L = span of bearings adjacent to a crank measured from inner edge to inner edge, in inches or millimetres.

A and **B** are coefficients dependent upon the designed maximum and mean indicated pressures and are found from **Table I.**

Where the designed maximum pressure and/or the designed mean indicated pressure are intermediate between the standard pressures given in **Table I.**, the coefficients **A** and **B** are to be found by interpolation between those given in the Table.

For heavy oil engines, with not more than three cylinders, driving auxiliary machinery the diameters of the crankshafts may be five per cent less than given by the foregoing formula.

3. **Crank Webs of Solid Forged Shafts.**—In solid forged shafts the breadth of the webs should not be less than 1·33 times and the thickness not less than ·56 times the diameter of the shaft as found by the foregoing formula, or, if these proportions are departed from, the webs are to be of equivalent strength.

4. **Crank Webs of Built Shafts.**—(*a*) The dimensions of the crank webs of built shafts are not to be less than those given by the following formulæ :—

$$h = \frac{\cdot 625 \times d}{t}$$

$$t = \sqrt{\frac{\cdot 12 \times d^3}{h}}$$

where h is the thickness of the web, measured parallel to the axis, in inches or millimetres,

t is the thickness of metal around the eyeholes measured radially, in inches or millimetres,

d is the diameter required for the crank shaft, in inches or millimetres.

(*b*) Crank webs are to be securely shrunk on the body pieces and crank pins. If dowels are not fitted at the junction of the body pieces and webs, the yield point of the material of the webs is to be not less than 14 tons per square inch, and the shrinkage allowance is to be between $\frac{1}{550}$ and $\frac{1}{700}$ of the diameter of the shaft.

5. **Intermediate Shafts.**—The diameter of the intermediate shafts is not to be less than that given by the formulæ :—

$$\left.\begin{array}{l}\text{For engines having a maximum}\\ \text{pressure under 350 lb. per}\\ \text{square inch. Diameter of}\\ \text{intermediate shaft, in inches}\end{array}\right\} = C\sqrt[3]{\frac{B.H.P.}{R}}$$

(Table II.)

$$\left.\begin{array}{l}\text{For engines having a maximum}\\ \text{pressure of 350 and under}\\ \text{500 lb. per square inch. Dia-}\\ \text{meter of intermediate shaft,}\\ \text{in inches}\end{array}\right\} = C\sqrt[3]{\frac{B.H.P.}{R}}$$

(Table III.)

$$\left.\begin{array}{l}\text{For engines having a maximum}\\ \text{pressure of 500 to 700 lb. per}\\ \text{square inch. Diameter of}\\ \text{intermediate shaft, in inches}\end{array}\right\} = C\sqrt[3]{\frac{B.H.P.}{R}}$$

(Table IV.)

where **B.H.P.** = designed maximum brake horse power,

R = revolutions of engines per minute,

C is a coefficient found from **Tables II.** or **III.**, by interpolation from the values found for **A**, or from **Table IV.** by interpolation from the values found for **A** and the piston speeds.

In using **Tables II., III.** and **IV.** the appropriate value of **A** is found thus :—

$$A = \frac{D^2 \times S}{W \times d^2 \times R^2}$$

where **D** = diameter of cylinder, in inches,

S = length of stroke, in inches,

d = diameter of fly wheel, in feet,

R = revolutions of engines per minute,

W = total weight of fly wheel, in tons.

Where a fly wheel is not fitted, but where there are special balance weights at the crank webs, the value of **A** may be found from the formula :—

$$A = \frac{D^2 \times S}{6{\cdot}24 \times w \times r^2 \times R^2}$$

where **D** = diameter of cylinder, in inches,

S = length of stroke, in inches,

r = radius of gyration of balance weights, in feet,

R = revolutions of engines per minute,

w = total weight of balance weights, in tons.

Where a flywheel and special balance weights are fitted, the value of **A** may be found from the formula :—

$$A = \frac{D^2 \times S}{(6{\cdot}24 \times wr^2 + Wd^2) \times R^2}$$

6. **Fly Wheel Shaft.**—The diameter of the fly wheel shaft is to be at least equal to that of the crank shaft.

7. **Thrust Shafts.**—The diameter at the collars of thrust shafts transmitting torque is not to be less than 1·05 times that required for the intermediate shaft. Thrust shafts may be tapered down outside the collars to the diameter required for the intermediate shaft.

8. **Tube Shafts** (Shafts passing through stern tubes but not carrying the screw propellers).—The diameter of the tube shaft is not to be less than 1·05 times that required for the intermediate shaft, and any part of the shaft within the tube which may be exposed to sea water is not to be less than 1·075 times that required for the intermediate shaft.

9. **Screw Shafts** (Shafts carrying the screw propellers).—(*a*) The diameter of the screw shaft is not to be less than that given by the following formula :—

$$\text{Diameter of screw shaft, in inches or millimetres} = d + \frac{P}{C}$$

where d is the diameter required for the intermediate shafts, in inches or millimetres,

P is the diameter of the propeller, in inches or millimetres,

C = 144 when the shaft is fitted with a continuous liner, or

C = 100 when the shaft is not fitted with a continuous liner.

(*b*) Screw shafts which run in stern tubes may have the end forward of the stern gland tapered down to a diameter, at the coupling flange, of 1·05 times d.

(*c*) Screw shafts for ships intended to have the notation "Strengthened for Navigation in Ice," are to comply with the requirements of **Section 10, clause 8,** of **Rules for Steel Ships.**

10. **Bronze Liners on Shafts.**—(*a*) The thickness of liners fitted on screw shafts or on tube shafts, in way of the bushes, is not to be less than that given by the following formulæ :—

$$t = \frac{d + 9{\cdot}25}{32} \quad \text{or} \quad t_m = \frac{+ 235}{32}$$

where t is the thickness of the liner, in inches,

t_m is the thickness of the liner, in millimetres,

d is the diameter required for the screw or tube shaft under the liner, in inches or millimetres.

(*b*) The thickness of a continuous liner between the bushes is not to be less than $\frac{3}{4}t$ or $\frac{3}{4}t_m$.

(*c*) Continuous liners should be cast in one piece, or, if made of two or more lengths, the junctions of the separate pieces are to be made by fusion through the whole thickness of the liner.

(*d*) Liners are to be carefully shrunk on, or forced on to the shafts by hydraulic pressure. Pins are not to be used to secure the liners.

(*e*) If the liner does not fit tightly between the bearings in the stern tube, the space between the shaft and the liner is to be charged or forced with a plastic material insoluble in water and non-corrosive.

(*f*) Effective means are to be provided for preventing water from having access to the shaft at the part between the after end of the liner and the propeller boss.

11. **Stern Bush.**—The length of the bearing in the stern bush next to and supporting the propeller, is not to be less than 4 times the diameter required for the screw shaft under the liner.

12. **Couplings.**—(*a*) The diameter of the coupling bolts at the joining faces of the couplings is not to be less than that given by the following formula :—

$$\left.\begin{array}{l}\text{Diameter of coupling bolts,}\\ \text{in inches or millimetres...}\end{array}\right\} = \sqrt{\frac{d^3}{3{\cdot}5 \times n \times r}}$$

where d is the diameter required for the intermediate shafts, in inches or millimetres,

n is the number of bolts in the coupling,

r is the radius of the pitch circle of the bolts, in inches or millimetres,

(*b*) The thickness of the coupling flanges at the pitch circle of the bolt holes is not to be less than the diameter of the coupling bolts, at the face of the coupling. The thickness of the screw shaft coupling flange is not to be less than ·25 of the diameter required for the intermediate shaft.

(*c*) The radius of the curvature at the fillet where the flange starts from the shaft, should not be less than ·125 times the diameter of the shaft adjacent to the flange.

(*d*) Where couplings are separate from the shafts, provision is to be made to resist the astern pull.

13. **Bronze Propellers.**—Where bronze is used for propellers or propeller blades, it is to comply with the requirements of **Section 11** of the **Rules for Quality and Testing of Materials.**

TABLE I. FOR CRANK SHAFTS OF SINGLE ACTING ENGINES.

4 Cycle Single Acting Engines. — Number of Cylinders.	2 Cycle Single Acting Engines. — Number of Cylinders.	Values of Coefficients.									
		Maximum Pressure 300 lb. per sq. inch.				Maximum Pressure 400 lb. per sq. inch.					
		M.I.P. 40 lb. per sq. inch.		M.I.P. 60 lb. per sq. inch.		M.I.P. 40 lb. per sq. inch.		M.I.P. 60 lb. per sq. inch.		M.I.P. 80 lb. per sq. inch.	
		A	B	A	B	A	B	A	B	A	B
1, 2, 3 or 4	1 or 2	·017	·031	·026	·031	·013	·062	·025	·058	·036	·054
5 or 6	3	·027	·028	·036	·028	·025	·058	·038	·054	·050	·050
7 or 8	4	·028	·028	·040	·028	·026	·058	·040	·054	·061	·048
9 or 10	5	·030	·027	·044	·027	·028	·056	·048	·051	·068	·047
11 or 12	6	·031	·027	·045	·027	·027	·058	·051	·051	·070	·046
—	7	·033	·027	·049	·027	·034	·054	·058	·049	·076	·045
—	8	·036	·027	·053	·027	·038	·054	·064	·048	·079	·045
—	9	·041	·026	·058	·026	·043	·051	·070	·046	·090	·042
—	10	·045	·024	·065	·024	·045	·051	·072	·046	·099	·041
—	11	·044	·026	·064	·026	·046	·053	·074	·046	·104	·041
—	12	·045	·026	·067	·026	·047	·053	·076	·046	·109	·040
—	4 2 Firing together.	·040	·026	·057	·026	·036	·054	·059	·049	·085	·043
—	6 2 Firing together.	·045	·024	·061	·024	·041	·053	·069	·046	·093	·042
—	8 2 Firing together.	·064	·022	·086	·022	·060	·049	·096	·043	·133	·038
—	10 2 Firing together.	·071	·022	·094	·022	·074	·046	·112	·040	·142	·037
—	12 2 Firing together.	·065	·022	·091	·022	·073	·046	·112	·040	·147	·037

TABLE I.—*continued.* FOR CRANK SHAFTS OF SINGLE ACTING ENGINES.

4 Cycle Single Acting Engines. Number of Cylinders.	2 Cycle Single Acting Engines. Number of Cylinders.	Values of Coefficients. Maximum pressure 500 to 700 lb. per sq. inch.													
		M.I.P. 40 lb. per sq. inch.		M.I.P. 60 lb. per sq. inch.		M.I.P. 80 lb. per sq. inch.		M.I.P. 100 lb. per sq. inch.		M.I.P. 120 lb. per sq. inch.		M.I.P. 140 lb. per sq. inch.		M.I.P. 160 lb. per sq. inch.	
		A	B	A	B	A	B	A	B	A	B	A	B	A	B
1,2,3 or 4	1 or 2	·030	·067	·046	·067	·061	·067	·076	·067	·089	·067	·099	·067	·108	·067
5 or 6	3	·042	·064	·059	·064	·070	·064	·082	·064	·096	·064	·111	·064	·120	·064
7 or 8	4	·045	·062	·062	·062	·079	·062	·092	·062	·110	·062	·127	·062	·143	·062
9 or 10	5	·047	·061	·064	·061	·082	·061	·101	·061	·121	·061	·135	·061	·150	·061
11 or 12	6	·049	·061	·066	·061	·084	·061	·103	·061	·123	·061	·137	·061	·153	·061
—	7	·051	·061	·068	·061	·086	·061	·106	·061	·125	·061	·140	·061	·156	·061
—	8	·053	·061	·070	·061	·088	·061	·109	·061	·128	·061	·148	·061	·165	·061
—	9	·059	·058	·080	·058	·101	·058	·122	·058	·144	·058	·163	·058	·181	·058
—	10	·064	·057	·088	·057	·112	·057	·134	·057	·157	·057	·178	·057	·198	·057
—	11	·066	·056	·091	·056	·115	·056	·139	·056	·161	·056	·182	·056	·203	·056
—	12	·069	·056	·093	·056	·119	·056	·147	·056	·178	·056	·202	·056	·223	·056
—	4 2 Firing together.	·076	·054	·105	·054	·136	·054	·160	·054	·183	·054	·206	·054	·232	·054
—	6 2 Firing together.	·078	·053	·107	·053	·140	·053	·164	·053	·187	·053	·210	·053	·237	·053
—	8 2 Firing together.	·097	·050	·133	·050	·170	·050	·203	·050	·229	·050	·258	·050	·292	·050
—	10 2 Firing together.	·107	·049	·141	·049	·175	·049	·208	·049	·242	·049	·268	·049	·303	·049
—	12 2 Firing together.	·090	·051	·126	·051	·161	·051	·196	·051	·222	·051	·248	·051	·286	·051

TABLE II. FOR INTERMEDIATE SHAFTS OF SINGLE ACTING ENGINES.

MAXIMUM PRESSURE UNDER 350 LB. PER SQ. INCH.							
4 CYCLE SINGLE ACTING ENGINES. — NUMBER OF CYLINDERS.	2 CYCLE SINGLE ACTING ENGINES. — NUMBER OF CYLINDERS.	VALUES OF COEFFICIENT C WHERE					
		A = ·0015	A = ·0025	A = ·005	A = ·010	A = ·015	NO FLY WHEEL OR BALANCE WEIGHTS.
1 or 2	1	4·26	4·48	5·02	5·92	—	—
3 or 4	2	4·17	4·20	4·25	4·38	4·55	5·96
5 or 6	3	4·15	4·17	4·20	4·26	4·35	4·90
7 or 8	4	4·10	4·13	4·16	4·24	4·32	4·77
9 or 10	5	4·07	4·07	4·09	4·14	4·18	4·34
11 or 12	6	4·06	4·06	4·06	4·08	4·10	4·18
—	7	4·05	4·05	4·05	4·06	4·06	4·09
—	8	4·04	4·04	4·04	4·04	4·04	4·04
—	9	4·03	4·03	4·03	4·03	4·03	4·03
—	10	4·03	4·03	4·03	4·03	4·03	4·03
—	11	4·02	4·02	4·02	4·02	4·02	4·02
—	12	4·02	4·02	4·02	4·02	4·02	4·02
—	4 2 Firing together.	4·13	4·20	4·38	4·67	4·87	5·85
—	6 2 Firing together.	4·12	4·19	4·32	4·50	4·63	5·13
—	8 2 Firing together.	4·10	4·15	4·24	4·36	4·43	4·70
—	10 2 Firing together.	4·07	4·10	4·15	4·22	4·27	4·39
—	12 2 Firing together.	4·04	4·05	4·08	4·11	4·12	4·16

TABLE III. FOR INTERMEDIATE SHAFTS OF SINGLE ACTING ENGINES.

MAXIMUM PRESSURE 350 AND UNDER 500 LB. PER SQ. INCH.

4 Cycle Single Acting Engines. — Number of cylinders.	2 Cycle Single Acting Engines. — Number of cylinders.	Values of coefficient C where					
		A = ·0015	A = ·0025	A = ·005	A = ·010	A = ·015	No fly wheel or balance weights.
1 or 2	1	4·33	4·59	5·23	6·31	—	—
3 or 4	2	4·19	4·24	4·34	4·59	4·83	6·67
5 or 6	3	4·16	4·18	4·22	4·32	4·42	5·08
7 or 8	4	4·10	4·14	4·18	4·30	4·40	4·90
9 or 10	5	4·07	4·08	4·11	4·17	4·21	4·42
11 or 12	6	4·06	4·06	4·08	4·11	4·13	4·23
—	7	4·05	4·05	4·06	4·08	4·10	4·16
—	8	4·04	4·04	4·04	4·04	4·04	4·06
—	9	4·03	4·03	4·03	4·03	4·03	4·03
—	10	4·03	4·03	4·03	4·03	4·03	4·03
—	11	4·02	4·02	4·02	4·02	4·02	4·02
—	12	4·02	4·02	4·02	4·02	4·02	4·02
—	4 2 Firing together.	4·19	4·29	4·59	5·00	5·26	6·55
—	6 2 Firing together.	4·18	4·23	4·41	4·66	4·81	5·41
—	8 2 Firing together.	4·12	4·18	4·28	4·43	4·51	4·80
—	10 2 Firing together.	4·10	4·12	4·18	4·27	4·31	4·43
—	12 2 Firing together.	4·05	4·07	4·10	4·14	4·15	4·20

TABLE IV. FOR INTERMEDIATE SHAFTS OF SINGLE ACTING ENGINES.

MAXIMUM PRESSURE 500 TO 700 LB. PER SQ. INCH.

2 Cycle Single Acting Engines.

Number of Cylinders.	Values of A.	Values of Coefficient C for the following Piston Speeds in feet per Minute. 700 and below.	850	1000	1200 and above.
1 or 2	·0015	4·45	4·41	4·39	4·37
	·0025	4·75	4·70	4·64	4·58
	·005	5·40	5·26	5·11	4·96
3	·0015	4·22	4·21	4·20	4·18
	·0025	4·37	4·33	4·29	4·26
	·005	4·70	4·55	4·49	4·40
	·010	5·14	4·88	4·69	4·54
4	·0015	4·14	4·13	4·12	4·11
	·0025	4·22	4·19	4·17	4·15
	·005	4·38	4·31	4·25	4·21
	·010	4·61	4·47	4·33	4·26
	·015	4·75	4·52	4·38	4·28
5	·0015	4·07	4·07	4·07	4·05
	·0025	4·11	4·09	4·09	4·07
	·005	4·18	4·15	4·11	4·09
	·010	4·28	4·21	4·14	4·10
	·015	4·33	4·24	4·16	4·11
	No Fly Wheel or Balance Weights.	4·47	4·32	4·21	4·13
6	·0015 to ·010	4·06	4·06	4·06	4·06
	·015	4·10	4·06	4·06	4·06
	No Fly Wheel or Balance Weights.	4·15	4·06	4·06	4·06
7	All Values including No Fly Wheel or Balance Weights.	4·05	4·05	4·05	4·05
8	,,	4·04	4·04	4·04	4·04
9	,,	4·03	4·03	4·03	4·03
10	,,	4·03	4·03	4·03	4·03
11	,,	4·02	4·02	4·02	4·02
12	,,	4·02	4·02	4·02	4·02
4 2 Firing together.	·0015	4·87	4·78	4·70	4·63
	·0025	5·35	5·18	5·02	4·87
	·005	6·16	5·77	5·45	5·19
6 2 Firing together.	·0015	4·43	4·37	4·30	4·26
	·0025	4·66	4·54	4·46	4·36
	·005	5·06	4·79	4·61	4·48
	·010	5·41	5·02	4·74	4·55
8 2 Firing together.	·0015	4·24	4·20	4·17	4·15
	·0025	4·32	4·27	4·22	4·18
	·005	4·53	4·38	4·27	4·21
	·010	4·70	4·48	4·32	4·24
	·015	4·78	4·50	4·34	4·25
	No Fly Wheel or Balance Weights.	4·99	4·60	4·39	4·27
10 2 Firing together.	·0015	4·12	4·09	4·08	4·07
	·0025	4·16	4·13	4·10	4·08
	·005	4·24	4·18	4·13	4·08
	·010	4·32	4·21	4·15	4·10
	·015	4·35	4·22	4·16	4·10
	No Fly Wheel or Balance Weights.	4·42	4·25	4·17	4·12
12 2 Firing together.	·0015 to ·005	4·06	4·05	4·04	4·03
	·010, ·015 and No Fly Wheel or Balance Weights.	4·11	4·06	4·05	4·04

4 Cycle Single Acting Engines.

Number of Cylinders.	Values of A.	Values of Coefficient C for the following Piston Speeds in feet per Minute. 700 and below.	850	1000	1200 and above.
1, 2, 3 or 4	·0015	4·40	4·36	4·33	4·29
	·0025	4·66	4·59	4·50	4·45
	·005	5·16	4·95	4·78	4·64
	·010	5·72	5·34	5·05	4·81
5	·0015	4·27	4·26	4·23	4·21
	·0025	4·42	4·38	4·33	4·27
	·005	4·77	4·61	4·48	4·38
	·010	5·10	4·83	4·61	4·48
6	·0015	4·20	4·18	4·16	4·14
	·0025	4·30	4·26	4·22	4·19
	·005	4·52	4·40	4·30	4·24
	·010	4·75	4·53	4·38	4·28
	·015	4·88	4·60	4·43	4·30
	No Fly Wheel or Balance Weights.	5·27	4·78	4·52	4·35
7	·0015	4·17	4·14	4·13	4·12
	·0025	4·24	4·21	4·18	4·16
	·005	4·36	4·30	4·23	4·19
	·010	4·53	4·36	4·28	4·21
	·015	4·63	4·40	4·30	4·22
	No Fly Wheel or Balance Weights.	4·87	4·52	4·34	4·24
8	·0015	4·13	4·11	4·10	4·08
	·0025	4·18	4·15	4·12	4·10
	·005	4·27	4·21	4·16	4·13
	·010	4·37	4·25	4·19	4·14
	·015	4·43	4·27	4·20	4·15
	No Fly Wheel or Balance Weights.	4·58	4·34	4·23	4·17
9	·0015	4·10	4·09	4·08	4·07
	·0025	4·14	4·11	4·10	4·08
	·005	4·20	4·16	4·12	4·10
	·010	4·26	4·18	4·13	4·11
	·015	4·29	4·19	4·14	4·11
	No Fly Wheel or Balance Weights.	4·37	4·23	4·17	4·12
10	·0015 to ·015	4·13	4·09	4·06	4·06
	No Fly Wheel or Balance Weights.	4·22	4·14	4·10	4·06
11	All Values including No Fly Wheel or Balance Weights.	4·07	4·07	4·07	4·07
12	,,	4·05	4·05	4·05	4·05

Section 4.

DOUBLE ACTING ENGINES.

Rules for Determining Sizes of Shafts.

1. (*a*) The crank, intermediate and other shafts, if of ordinary mild steel having a tensile breaking strength of 28–32 tons per square inch, are to be of not less diameters than those given by the following formulæ.

The formulæ do not, however, take into consideration the possibility of severe torsional vibration stresses arising in the shafting.

Calculations of the torsional vibration characteristics for the dynamic system formed by the engine, shafting and propeller, also gearing or generators where these are interposed, are to be submitted for consideration, together with plans of all shafting. These calculations should include frequency tables for the one and two node natural frequencies, also three node where necessary, and particulars of the firing order. In drawing up frequency tables, the single amplitude of swing should be taken as one radian at the first mass at the end of the engine remote from the driving end. The vector summations are to be given for the relative angular displacements of the working cranks for all orders of vibration occurring at speeds less than 30 per cent. above the normal running speed.

Similar calculations are to be submitted for heavy oil engines of 100 B.H.P. or more driving auxiliary machinery used for essential services at sea.

In certain cases the Committee may consider it necessary for torsiograph readings to be taken from the machinery after fitting on board, for the purpose of verifying that serious critical speeds do not occur within the range of working speeds.

(*b*) Where shafts are proposed to be made of special high tensile steel, their sizes should be submitted for consideration.

2. **Crank Shafts.**—Where the designed maximum and mean indicated pressures are 500 and 100 lb. per square inch respectively, the diameter of the crankshaft of the main engines is not to be less than that given by the following formula :—

$$\left.\begin{array}{l}\text{Diameter of crank}\\ \text{shaft, in inches}\\ \text{or millimetres}\end{array}\right\} = \sqrt[3]{D^2 \times (AS + BL)}$$

where D = diameter of cylinder, in inches or millimetres,
S = length of stroke, in inches or millimetres,
L = span of bearings adjacent to a crank, measured from inner edge to inner edge, in inches or millimetres.
A and B are coefficients found from **Table V.**

Where the designed maximum and mean indicated pressures are other than 500 and 100 lb. per square inch respectively, or where special arrangements of cranks and firing orders are adopted, also where balance weights are fitted to the crank webs and only light flywheels are fitted, the sizes of the shafting will be specially considered.

For heavy oil engines, with not more than three cylinders, driving auxiliary machinery the diameters of the crankshafts may be five per cent less than given by the foregoing formula.

3. **Crank Webs of Solid Forged Shafts.**—In solid forged shafts the breadth of the webs should not be less than 1·33 times and the thickness not less than ·56 times the diameter of the shaft as found by the foregoing formula, or, if these proportions are departed from, the webs are to be of equivalent strength.

4. **Crank Webs of Built Shafts.**—(*a*) The dimensions of the crank webs of built shafts are not to be less than those given by the following formulæ :—

$$h = \cdot 625 \times d$$

$$t = \sqrt{\frac{\cdot 12 \times d^3}{h}}$$

where h is the thickness of the web, measured parallel to the axis, in inches or millimetres,
t is the thickness of metal around the eyeholes, measured radially, in inches or millimetres,
d is the diameter required for the crank shaft, in inches or millimetres.

(*b*) Crank webs are to be securely shrunk on the body pieces and crank pins. If dowels are not fitted at the junction of the body pieces and webs, the yield point of the material of the webs is to be not less than 14 tons per square inch, and the shrinkage allowance is to be between $\frac{1}{550}$ and $\frac{1}{700}$ of the diameter of the shaft.

5. **Intermediate Shafts.**—Where the designed maximum pressure does not exceed 500 lb. per square inch, the diameter of the intermediate shaft is to be not less than that given by the formula :—

$$\left.\begin{array}{l}\text{Diameter of intermediate shaft,}\\ \text{in inches} \quad \ldots\end{array}\right\} = C \sqrt[3]{\frac{B.H.P.}{R}}$$

Where $B.H.P.$ = Designed maximum brake horse power,
R = Revolutions of engines per minute,
C is a coefficient found from **Table VI.** by interpolation from the values found for A and the piston speeds.

In using **Table VI.** the appropriate value of **A** is found hus :—

$$A = \frac{D^2 \times S}{W \times d^2 \times R^2}$$

where **D** = diameter of cylinder, in inches,
S = length of stroke, in inches,
d = diameter of fly wheel, in feet,
R = revolutions of engines per minute,
W = total weight of fly wheel, in tons.

Where a fly wheel is not fitted, but where there are special balance weights at the crank webs, the value of **A** may be found from the formula :—

$$A = \frac{D^2 \times S}{6{\cdot}24 \times w \times r^2 \times R^2}$$

where **D** = diameter of cylinder, in inches,
S = length of stroke, in inches,
r = radius of gyration of balance weights, in feet,
R = revolutions of engines per minute,
w = total weight of balance weights, in tons.

Where a fly wheel and special balance weights are fitted the value of **A** may be found from the formula :—

$$A = \frac{D^2 \times S}{(6{\cdot}24 \times wr^2 + Wd^2) \times R^2}$$

TABLE V. FOR CRANK SHAFTS OF DOUBLE ACTING ENGINES.

500 LB. PER SQ. INCH MAXIMUM PRESSURE AND 100 LB. PER SQ. INCH MEAN INDICATED PRESSURE (TOP AND BOTTOM).

2 Cycle Double Acting Engines.				4 Cycle Double Acting Engines.				
Number of Cylinders.	Arrangement of Cranks.	Values of Coefficients. A	Values of Coefficients. B	Number of Cylinders.	Arrangement of Cranks.	Particulars of Firing.	Values of Coefficients. A	Values of Coefficients. B
1	—	·063	·044	1	—	—	·063	·044
2	—	·104	·038	2	—	—	·104	·038
3	—	·076	·042	3	—	—	·094	·039
4		·116	·037	4	—	—	·159	·034
4		·159	·034	6		No Simultaneous Firing.	·127	·037
5		·127	·036	8		Two Cylinder Ends Fire together.	·200	·032
6		·141	·035	6		Two Cylinder Ends Fire together.	·185	·032
6		·152	·034	8		Four Cylinder Ends Fire together.	·355	·028
7		·149	·034					
8		·189	·032					
9		·196	·032					
6		·167	·033					
8		·324	·028					

TABLE VI. FOR INTERMEDIATE SHAFTS OF DOUBLE ACTING ENGINES.

500 LB. PER SQ. INCH MAXIMUM PRESSURE.

2 Cycle Double Acting Engines.						4 Cycle Double Acting Engines.					
Number of Cylinders.	Values of A.	Values of coefficient C for the following piston speeds in feet per minute.				Number of Cylinders.	Values of A.	Values of coefficient C for the following piston speeds in feet per minute.			
		700 and below.	850	1000	1200 and above.			700 and below.	850	1000	1200 and above.
1	·0015	4·48	4·47	4·46	4·44	1	·0015	4·59	4·57	4·55	4·52
	·0025	4·82	4·79	4·75	4·71		·0025	5·01	4·96	4·91	4·85
2 Cranks at 90°	·0015	4·21	4·20	4·19	4·18	2 Cranks at 90°	·0015	4·54	4·52	4·47	4·44
	·0025	4·35	4·31	4·28	4·26		·0025	4·89	4·81	4·73	4·64
	·005	4·68	4·58	4·50	4·43						
	·010	5·15	4·92	4·74	4·59						
2 Cranks at 180°	·0015	4·69	4·65	4·61	4·57	2 Cranks at 180°	·0015	4·97	4·91	4·85	4·78
	·0025	5·14	5·06	4·95	4·86		·0025	5·54	5·41	5·27	5·15
3	·0015	4·11	4·11	4·10	4·09	3	·0015	4·53	4·48	4·45	4·39
	·0025	4·17	4·16	4·14	4·13		·0025	4·86	4·75	4·65	4·56
	·005	4·30	4·25	4·21	4·18		·005	5·45	5·20	4·98	4·80
	·010	4·50	4·37	4·28	4·22						
	·015	4·62	4·47	4·32	4·25						
	No Fly Wheel or Balance Weights	5·15	4·70	4·47	4·31						
4	·0015	4·20	4·18	4·16	4·15	4	·0015	4·69	4·61	4·53	4·47
	·0025	4·30	4·26	4·22	4·19		·0025	5·11	4·89	4·74	4·62
	·005	4·53	4·41	4·31	4·25		·005	5·65	5·24	5·03	4·81
	·010	4·78	4·56	4·40	4·30						
	·015	4·91	4·63	4·47	4·32						
	No Fly Wheel or Balance Weights	5·35	4·84	4·55	4·38						
5	·0015 to ·0025	4·05	4·04	4·04	4·04	6 No Simultaneous Firing.	·0015	4·09	4·08	4·07	4·06
	·005 to ·015	4·10	4·07	4·06	4·05		·0025	4·13	4·10	4·09	4·07
	No Fly Wheel or Balance Weights	4·16	4·10	4·07	4·06		·005	4·18	4·14	4·11	4·08
							·010	4·23	4·17	4·12	4·09
							·015	4·26	4·18	4·13	4·10
							No Fly Wheel or Balance Weights	4·34	4·21	4·14	4·11
6	·0015 to ·0025	4·06	4·05	4·04	4·04						
	·005 to ·015	4·12	4·09	4·07	4·05						
	No Fly Wheel or Balance Weights	4·16	4·11	4·08	4·06						
7	All Values, including No Fly Wheel or Balance Weights.	4·04	4·04	4·04	4·04	8 2 Cylinder Ends Fire together.	·0015	4·15	4·13	4·10	4·08
							·0025	4·20	4·16	4·13	4·10
							·005	4·28	4·20	4·15	4·12
							·010	4·35	4·23	4·17	4·13
							·015	4·38	4·24	4·18	4·13
							No Fly Wheel or Balance Weights	4·48	4·27	4·19	4·14
8	,,	4·03	4·03	4·03	4·03						
9	,,	4·02	4·02	4·02	4·02						
6	·0015	4·19	4·17	4·15	4·13	6 2 Cylinder Ends Fire together.	·0015	4·92	4·78	4·65	4·53
	·0025	4·27	4·23	4·19	4·16		·0025	5·31	5·06	4·84	4·67
	·005	4·45	4·31	4·24	4·19						
	·010	4·60	4·40	4·28	4·21						
	·015	4·68	4·46	4·30	4·22						
	No Fly Wheel or Balance Weights	4·91	4·54	4·35	4·25						
8	·0015	4·32	4·26	4·21	4·18	8 4 Cylinder Ends Fire together.	·0015	5·07	4·84	4·67	4·53
	·0025	4·47	4·34	4·26	4·21		·0025	5·39	5·07	4·80	4·62
	·005	4·64	4·46	4·31	4·23						
	·010	4·80	4·52	4·35	4·25						
	·015	4·86	4·55	4·37	4·26						
	No Fly Wheel or Balance Weights	5·03	4·62	4·40	4·28						

6. **Fly Wheel Shaft.**—The diameter of the fly wheel shaft is to be at least equal to that of the crank shaft.

7. **Thrust Shafts.**—The diameter at the collars of thrust shafts transmitting torque is not to be less than 1·05 times that required for the intermediate shaft. Thrust shafts may be tapered down outside the collars to the diameter required for the intermediate shaft.

8. **Tube Shafts** (Shafts passing through stern tubes but not carrying the screw propellers).—The diameter of the tube shaft is not to be less than 1·05 times that required for the intermediate shaft, and any part of the shaft within the tube which may be exposed to sea water is not to be less than 1·075 times that required for the intermediate shaft.

9. **Screw Shafts** (Shafts carrying the screw propellers).—(*a*) The diameter of the screw shaft is not to be less than that given by the following formula:—

$$\text{Diameter of screw shaft, in inches or millimetres} = d + \frac{P}{C}$$

where d is the diameter required for the intermediate shafts, in inches or millimetres,

P is the diameter of the propeller, in inches or millimetres,

C = 144 when the shaft is fitted with a continuous liner, or

C = 100 when the shaft is not fitted with a continuous liner.

(*b*) Screw shafts which run in stern tubes may have the end forward of the stern gland tapered down to a diameter, at the coupling flange, of 1·05 times d.

(*c*) Screw shafts for ships intended to have the notation "Strengthened for Navigation in Ice," are to comply with the requirements of **Section 10, clause 8,** of **Rules for Steel Ships.**

10. **Bronze Liners on Shafts.**—(*a*) The thickness of liners fitted on screw shafts or on tube shafts, in way of the bushes, is not to be less than that given by the following formulæ:—

$$t = \frac{d + 9{\cdot}25}{32} \quad \text{or} \quad t_m = \frac{d + 235}{32}$$

where t is the thickness of the liner, in inches,

t_m is the thickness of the liner, in millimetres,

d is the diameter required for the screw or tube shaft under the liner, in inches or millimetres.

(*b*) The thickness of a continuous liner between the bushes is not to be less than $\frac{3}{4}t$ or $\frac{3}{4}t_m$.

(*c*) Continuous liners should be cast in one piece, or if made of two or more lengths, the junctions of the separate pieces are to be made by fusion through the whole thickness of the liner.

(*d*) Liners are to be carefully shrunk on, or forced on to the shafts by hydraulic pressure. Pins are not to be used to secure the liners.

(*e*) If the liner does not fit tightly between the bearings in the stern tube, the space between the shaft and the liner is to be charged or forced with a plastic material insoluble in water and non-corrosive.

(*f*) Effective means are to be provided for preventing water from having access to the shaft at the part between the after end of the liner and the propeller boss.

11. **Stern Bush.**—The length of the bearing in the stern bush next to and supporting the propeller, is not to be less than 4 times the diameter required for the screw shaft under the liner.

12. **Couplings.**—(*a*) The diameter of the coupling bolts at the joining faces of the couplings is not to be less than that given by the following formula:—

$$\left.\begin{array}{l}\text{Diameter of coupling bolts,}\\ \text{in inches or millimetres...}\end{array}\right\} = \sqrt{\frac{d^3}{3{\cdot}5 \times n \times r}}$$

where d is the diameter required for the intermediate shafts, in inches or millimetres,

n is the number of bolts in the coupling,

r is the radius of the pitch circle of the bolts, in inches or millimetres.

(*b*) The thickness of the coupling flanges at the pitch circle of the bolt holes is not to be less than the diameter of the coupling bolts, at the face of the coupling. The thickness of the screw shaft coupling flange is not to be less than ·25 of the diameter required for the intermediate shaft.

(*c*) The radius of the curvature at the fillet where the flange starts from the shaft, should not be less than ·125 times the diameter of the shaft adjacent to the flange.

(*d*) Where couplings are separate from the shafts, provision is to be made to resist the astern pull.

13. **Bronze Propellers.**—Where bronze is used for propellers or propeller blades, it is to comply with the requirements of **Section 11** of the **Rules for Quality and Testing of Materials.**

Section 5.

GENERAL REQUIREMENTS FOR SINGLE AND DOUBLE ACTING ENGINES.

1. Cylinder liners are to be tested internally by hydraulic pressure, over their whole length; the pressure is to be not less than 100 lb. per square inch applied for a period of not less than 30 minutes.

2. The water jackets of the cylinders, and the water passages of the cylinder covers and pistons, are to be tested by hydraulic pressure to 30 lb. per square inch.

3. The exhaust pipes and silencer are to be efficiently water cooled or lagged to prevent damage by heat, and if the exhaust is led overboard near the water-line, means are to be provided to prevent water from being syphoned back to the engine.

4. The cylinders are to be fitted with safety valves loaded to not more than 40 per cent above the designed maximum pressure in the cylinders and discharging where no damage can occur.

Cylinders not exceeding 6 inches diameter need not be fitted with safety valves.

Where compressed air is not used for starting purposes safety valves need not be fitted on cylinders not exceeding 8 inches diameter.

5. The air compressors and their coolers are to be so made as to be easy of access for overhaul and adjustment and each compressor is to be fitted with a safety valve adjusted to the maximum working pressure.

6. Where the fuel is injected into the cylinders by air pressure, one main air compressor should be provided for each main engine.

In single screw ships, an auxiliary air compressor is to be provided of sufficient capacity to enable the engines to be kept at work at not less than two-thirds of the normal sea power.

In twin screw ships where two sets of compressors are fitted, the auxiliary compressor is to be of sufficient capacity to enable one main engine to be kept at work at not less than two-thirds of its normal sea power. If in such engines each main compressor is sufficiently large to supply both engines, a smaller auxiliary compressor will be sufficient.

7. A small auxiliary compressor, which does not require compressed air for starting up, is to be fitted for first charging the air receivers.

8. At least one high pressure air receiver is to be arranged with connections to enable it to be used for fuel injection, in case the working receiver of either main engine is out of use from any cause.

9. Where only one scavenging blower is fitted, alternative or duplicate means for driving the blower are to be provided ready for use.

10. Engines intended for driving electric generators are to comply with the requirements of the **Rules for Electric Propelling Machinery, Section 4,** and of the **Rules for Electrical Equipment, Section 2, clauses 1, 13, 14, 17, 18** and **20** where these are applicable.

For pumping arrangements, cooling water and lubricating oil systems *see* **Rules for Pumping and Piping.**

Section 6.

AIR RECEIVERS.

1. Compressed air receivers for starting air are to be supplied of sufficient capacity to permit of twelve consecutive startings of each main engine without replenishment.

2. Cylindrical receivers for containing air under high pressure, used either for starting or for the injection of fuel in oil engines, may be made either of seamless steel or of welded, or riveted, steel plates.

3. **Welded Receivers.**—Receivers of fusion or forge welded construction are to comply with the **Rules for Welded Pressure Vessels.**

4. **Riveted Receivers.**—Receivers of riveted construction are to comply with the **Rules for Cylindrical Boilers,** but where end plates are dished to partial spherical form, subject to pressure on the concave side, and not fitted with stays, the following formula may be used:—

$$WP = \frac{576 \times S \times T}{R}$$

where T = thickness of the end in inches after dishing,

WP = working pressure in lb. per square inch.

R = inside radius of curvature of the end in inches, which is not to exceed the diameter of the shell.

S = ultimate tensile strength of the plates in tons per square inch.

The inside corner radius is not to be less than four times the thickness of the end plate and in no case less than 2·5 inches.

Where the end is provided with a flanged manhole the thickness of the end in inches determined by the foregoing formula is to be increased by $\frac{1}{8}$ inch and the depth of the manhole flange, measured in inches from the outer surface at the minor axis shall be not less than $F = \sqrt{T_1 \times W}$

where T_1 = the required thickness of the end plate in inches.

W = the minor axis of the manhole in inches.

5. **Seamless Receivers.**—In the case of seamless receivers, the rules for material will be the same as for boiler shells, but the permissible extension may be 2 per cent. less than that required with boiler plates.

The thicknesses of seamless receivers are to be verified by the Surveyor before the ends are closed in, and at this time the Surveyor is to select and mark the test pieces required from either of the open ends of the tube. The test pieces are to be subjected to the same heat treatment as that given to the receivers.

6. The permissible working pressure for seamless receivers is to be determined by the following formulæ :—

$$WP = \frac{C \times S \times (t - 4)}{D}$$

for thicknesses of $\frac{5}{8}$ inch and above.

$$WP = \frac{C \times S \times (t - 2)}{D}$$

for thicknesses below $\frac{5}{8}$ inch.

where **WP** is the working pressure in lb. per square inch,

S is the minimum tensile strength of the steel shell plates in tons per square inch,

t is the thickness of the shell plates in 32nds of an inch,

D is the internal diameter in inches,

C=38·5 for receivers of thickness $\frac{5}{8}$ inch and above

C=34·5 for receivers of thickness below $\frac{5}{8}$ inch.

7. Each seamless receiver is to be carefully annealed after manufacture, and before the hydraulic test.

8. Each seamless receiver is to be subjected to a hydraulic test of twice the working pressure, which it shall withstand without permanent set.

9. Each receiver made of riveted steel plates for pressures up to 300 lb. per sq. inch is to be tested by hydraulic pressure to $1\frac{1}{2}$ times the working pressure, plus 50 lb. per sq. inch. Where higher working pressures are used, the test pressure need not be more than 200 lb. per sq. inch above the working pressure.

10. All receivers above six inches internal diameter are to be so made that the internal surfaces may be examined, and, wherever practicable, the openings for this purpose are to be sufficiently large for access. Means are to be provided for cleaning the inner surfaces by steam, or otherwise.

11. Each receiver which can be isolated from a safety valve is to be provided with a suitable fusible plug to discharge the contents in case of fire.

12. Each receiver is to be fitted with a drain arrangement at its lowest part, permitting oil and condensed water to be blown out.

For scantlings of compressed air and oil fuel pressure pipes *see* **Rules for Pumping and Piping.**

Section 7.

MISCELLANEOUS.

1. All oil fuel pipes, tanks and their fittings are to comply with the requirements of **Section 20, Rules for Steel Ships,** and the **Rules for Pumping and Piping.**

2. Special attention is to be given to the ventilation of the engine room.

3. If the auxiliaries are worked by electricity, the cables, motors, control gear and electrical spares in connection with them are to be in accordance with the **Rules for Electrical Equipment.**

Section 8.

SPARE GEAR.

In ships engaged on ocean going service, the articles mentioned in the following list (so far as they are applicable) will be required to be carried, viz. :—

*For a single screw ship a propeller, or two blades with studs and nuts for one blade. The propeller or blades may be of cast iron, except for ships having the notation "Strengthened for Navigation in Ice."

For Main Engines.

*1 cylinder cover of each design used, complete with all valves, valve casings, springs and other fittings and, in addition, one complete set of valves for one cylinder, with their casings, springs and other fittings.

Fuel needle valves for half the number of cylinders of each engine.

*1 piston complete, with all piston rings, studs and nuts.

1 set of piston rings for one piston.

*1 complete cylinder liner.

Telescopic cooling pipes for one piston.

*1 set of wheels for the cam shaft drive of one engine or six separate links with pins and rollers where chain drive is used for cam shaft or scavenge blower.

1 set of studs and nuts for one cylinder cover of each design used.

* Not required for ships engaged on short voyages.

For Main Engines—*Continued.*

1 set of rubber rings for liner joints.

2 cross head bearing bolts and nuts, or one gudgeon pin where trunk pistons are used.

1 complete crank pin bearing.

1 set of top end bearings.

1 set of packings for one piston rod for Double Acting Engines.

*1 piston rod for Double Acting Engines.

2 crank pin bearing bolts and nuts of each size used.

2 main bearing bolts and nuts.

1 set of pads of each hand for one face of Michell Thrust Block.

1 set of coupling bolts of each size used.

For Main Engine Air Compressors and Pumps.

1 set of piston rings for one piston of each size used in the air compressor.

1 half set of suction and delivery valves for each size used in the air compressor.

Not less than 10 per cent. of suction and delivery valves for the scavenge air pump where lift valves are used.

1 impeller, impeller shaft and bearings where scavenge blowers are used. Where more than one scavenge blower is fitted, and one of these is additional to the required capacity of blower or blowers, under full working conditions, no spare parts need be supplied provided the additional blower is arranged to be easily substituted for the working blowers.

1 set of bilge pump valves and seats.

1 additional fuel pump or all working parts for one fuel pump.

For each size of Auxiliary Heavy Oil Engine.

1 complete set of valves for one cylinder, with their springs and other fittings.

Fuel needle valves for half the number of cylinders.

1 set of piston rings for one piston.

1 set of studs and nuts for one cylinder cover.

2 crosshead bearing bolts and nuts, or one gudgeon pin where trunk pistons are used.

For each size of Auxiliary Heavy Oil Engine—*Continued.*

2 crank pin bearing bolts and nuts of each size used.

1 complete crank pin bearing.

1 complete top end bearing.

2 main bearing bolts and nuts.

1 set of piston rings for one piston of each size used in the air compressor.

1 half set of suction and delivery valves for each size used in the air compressor.

1 additional fuel pump or all working parts for one fuel pump.

For Auxiliary Air Compressors.

1 set of piston rings for one piston of each size used.

1 half set of suction and delivery valves of each size used.

For Auxiliary Pumps.

1 set of valves of each size used for the liquid end of each pump.

For Donkey Boilers used for essential services at sea.

1 set of valves for the water end of the feed pump.

1 valve lid for feed check.

6 tube stoppers.

1 set of oil fuel burner nozzles complete with atomisers etc., for one boiler.

General.

A quantity of assorted studs, bolts and nuts.

Steel bars and plates of various sizes.

A length of pipe of each size used, for the fuel delivery and injection air pipes to the main and auxiliary power cylinders, and the air delivery from the main and auxiliary compressors to the receivers, with unions and flanges suitable for each.

Section 9.

PERIODICAL SURVEYS.

For periodical surveys of the machinery *see* **Section 4, Periodical Survey Requirements, "Petrol, Paraffin, and Heavy Oil Engines."**

71, Fenchurch Street, London, E.C.3.
15th December, 1949.

* Not required for ships engaged on short voyages.

ELECTRIC PROPELLING

MACHINERY.

INDEX

ELECTRIC PROPELLING MACHINERY.

	Section.	Clause.	Page.
Alterations and Additions	2	1	357
Alternating Current Systems	6	—	359
„ excitation	6	6	360
„ limiting pressures ...	6	1	359
„ propulsion generators ...	6	3	359
„ „ motors ...	6	4	360
„ stability	6	5	360
„ stator laminations ...	6	2	359
Alternators, Motors and Direct Current Generators (Appendix 4)	—	—	441
Batteries, Secondary	10	—	365
„ „ capacity ...	10	2	365
„ „ general	10	1	365
Bus-bars and Connections (Appendix 1)	—	—	437
Compasses, Interference with	9	7	365
Conductors and Cables	9	—	364
Cables for alternating currents ...	9	4	365
„ installing and fixing of ...	9	3	364
„ insulation and protective covering of	9	2	364
„ sockets	9	5	365
„ synchronous motor	9	6	365
Conductors	9	1	364
„ interference with Magnetic compasses	9	7	365
Construction	2	—	357
„ novel form of ...	2	5	357
Control Gear and Switchboards, General Requirements for Propulsion ...	8	—	361
„ „ arcing tips	8	2(*t*)	362
„ „ auxiliary power ...	8	14	364
„ „ bridge or deck control	8	6	363
„ „ connections ...	8	2(*g*)	361
„ „ direct current systems	8	9	363
„ „ discharge protection	8	8	363
„ „ earth detection ...	8	4	362
„ „ exposed parts exceeding 250 volts to earth	8	5(*d*)	363
„ „ fusible cut-outs ...	8	2(*n*)	362
„ „ fuses for voltmeters, pilot lamps, etc. ..	8	2(*j*)	362
„ „ general construction	8	2	361
„ „ instrument cases, earthing ...	8	2(*s*)	362
„ „ instruments and gauges	8	7	363
„ „ interlocking ...	8	2(*p*)	362
„ „ labels	8	2(*i*)	362
„ „ mechanical protection	8	5	363
„ „ overload and short circuit protection	8	3	362
„ „ position	8	1	361
„ „ resistances	8	11	363
„ „ reversing levers and handwheels ...	8	13	364
„ „ reversing switches	8	10	363
„ „ rust prevention ...	8	2(*x*)	362
„ „ speed control ...	8	15	364
„ „ switches and circuit breakers ...	8	2(*m*)	362
„ „ temperature alarm	8	12	364
Direct Current Systems	7	—	361
„ brush gear	7	3	361
„ excitation	7	4	361
„ limiting pressures ...	7	1	361
„ overspeed protection ...	7	5	361
„ propulsion generators and motors	7	2	361
Direct Current Generators (Appendix 4)	—	—	441
Electric Generators and Motors, including Exciters, Balancers, Boosters (Appendix 3)	—	—	438
Electric Propulsion Machines, General Requirements of	5	—	358
„ „ coolers	5	3	358
„ „ excitation ...	5	8	358
„ „ facilities for inspection and repair ...	5	9	359
„ „ foundation and bilges	5	13	359
„ „ heating when idle	5	6	358
„ „ insulation ...	5	1	358
„ „ lubrication ...	5	11	359
„ „ manœuvring ...	5	14	359
„ „ mechanical protection	5	10	359
„ „ position in ship ...	5	12	359
„ „ shaft currents ...	5	7	358
„ „ terminals	5	2	358
„ „ thermometers ...	5	4	358
„ „ ventilation ...	5	5	358
Electric Propulsion Machines for Alternating Current Systems ...	6	—	359
Electric Propulsion Machines for Direct Current Systems	7	—	361
General	1	—	357
Oil Engines for Propulsion Generators	4	—	358
„ „ critical speed ...	4	2	358
„ „ governing	4	1	358
„ „ rating	4	3	358
Plans, Submission of	2	3	357
Spare Gear	12	—	366
„ for generators, motors and exciters	12	1	366
„ for switch and control gear ...	12	2	366
„ general	12	3	366
„ storing	12	4	366
Steam Engines for Propulsion Generators	3	—	357
„ „ bled steam	3	6	357
„ „ emergency governor ...	3	4	357
„ „ exhaust steam turbines	3	5	357
„ „ governing	3	1	357
„ „ maximum speed ...	3	3	357
„ „ mechanical balance ...	3	8	358
„ „ speed control ...	3	2	357
„ „ torque limiting ...	3	7	357
Trials	11	—	365
„ ship trials	11	2	365
„ works tests	11	1	365

RULES FOR ELECTRIC PROPELLING MACHINERY.

(For Tables, see pages 416–436).

Section 1.

GENERAL.

In ships propelled by electrical machinery, either wholly or partly by this means, the Rules with regard to machinery are the same as those relating to steam engines so far as regards the testing of material used in their construction and fitting of sea connections, suction and discharge pipes, shafting, stern tubes and propellers.

The following rules are also to be observed. These relate to the electric propulsion equipment, with such references to the mechanical equipment as are required for the successful operation of the combined system. Such requirements are additional to those detailed in the appropriate sections of the Rules.

Section 2.

CONSTRUCTION.

1. In ships built under special survey and fitted with electric propelling machinery, the whole of the electrical machinery, including switch gear, control gear, cables, main and auxiliary generators, motors and exciters, are to be constructed under special survey.

Any alterations and additions to the installation which are made are to be carried out under the inspection, and to the satisfaction, of the Surveyors.

2. In the cases of electric propelling machinery to engines being built under special survey, the distinguishing mark ✠ will be noted in the Register Book in red, thus:— ✠LMC or ✠NE.

3. In order to facilitate the inspection, the plans of the machinery, control gear, cables and electric circuits are to be submitted for approval.

4. The Surveyors are to examine the materials and workmanship from the commencement of the work until the final test of the machinery under full power working conditions has been satisfactorily carried out. Any defects are to be pointed out as early as possible.

5. Any novelty in the construction, operation or application of the machinery is to be reported to the Committee and submitted for approval.

Section 3.

STEAM ENGINES FOR PROPULSION GENERATORS.

1. **Governing.**—An efficient governor is to be incorporated, which is to be arranged so that when operating at rated speed and the rated load is thrown off, the maximum variation in speed is not to be sufficient to bring the emergency governor into operation, and the permanent variation is not to exceed four per cent of the rated speed.

NOTE:—Exhaust steam turbines working in conjunction with reciprocating engines require an emergency overspeed governor only.

2. **Speed Control.**—When the propeller speed is arranged to be varied by controlling the engine speed the control is to be arranged to permit increments and decrements of speed not exceeding one per cent of maximum speed between 50 per cent and 100 per cent of maximum rated speed.

3. **Maximum Speed.**—The engines are to be capable of withstanding for five minutes without injury a speed of 15 per cent in excess of the maximum rated speed.

4. **Emergency Governor.**—An emergency overspeed governor, independent of the main governor, is to be arranged to trip the throttle valve when the speed exceeds the rated maximum running speed by not less than 10 nor more than 15 per cent. It is also to be arranged for hand tripping.

5. **Mixed Pressure Turbines.**—If, in the case of a turbine, exhaust steam can be admitted to the lower stages, an automatic shut-off controlled by the governor and emergency trip is also to be provided.

6. **Bled Steam.**—When provision is made for bleeding steam from the intermediate stages of a turbine, non-return valves, or positive shut off valves operated by the emergency governor, are to be fitted.

7. **Torque Limiting.**—In cases where the arrangements permit a propelling motor to be connected to generating plant having a continuous capacity higher than the motor

rating, means are to be provided to limit the continuous input to the motor to approximately five per cent above the torque for which the shaft is approved.

8. **Mechanical Balance.**—The engines and generators are to be so constructed, erected and supported that when running at any and every working speed all revolving and reciprocating parts are well balanced so as not to give rise to any appreciable vibration.

For lubricating oil supply to steam turbine driven sets *see* **Rules for Pumping and Piping.**

Section 4.

OIL ENGINES FOR PROPULSION GENERATORS.

1. **Governing.**—An efficient governor capable of rapidly shutting off the flow of oil fuel is to be provided. It is to keep the engine speed within seven per cent momentarily and three and a half per cent permanently at full speed when full load is removed.

2. **Critical Speed.**—When coupled to the generator or generators, the combined set must not run in the vicinity of a serious critical at any designed running speed, or range of speeds.

Calculations of the torsional vibration characteristics for the dynamic system formed by the engine and generator or generators are to be submitted for consideration, together with plans of all shafting.

These calculations should include the particulars required by **Sections 3** and **4, clause 1 (a) Rules for Heavy Oil Engines.**

In certain cases the Committee may consider it necessary for torsiograph readings to be taken from the machinery after fitting on board, for the purpose of verifying that serious critical speeds do not occur within the range of working speeds.

3. **Rating.**—The engine is to be capable, for periods of one hour, of developing a load 10 per cent above its rated output within the limits of variation in speed defined in **clause 1** without undue heating of the engine or other mechanical trouble. The rated output in B.H.P. (unless otherwise approved) is to be the load required to drive the generators and all direct coupled auxiliaries at their continuous maximum rating for a period of 12 hours when working with a barometric pressure of 30 inches of mercury and a surrounding air temperature of 62° F. (16·7° C.).

Section 5.

GENERAL REQUIREMENTS OF ELECTRIC PROPULSION MACHINES.

1. **Insulation.**—(*a*) All windings are to be insulated and treated to resist moisture, sea air and oil vapour.

(*b*) All windings are to be insulated from the frame with mica or micanite. Where it is desired to use other types of insulation, particulars regarding the behaviour, properties and life of the materials are to be submitted for consideration.

2. **Terminals.**—The terminals are to be so secured and spaced or shielded that they cannot be accidentally earthed, short circuited or touched. Cable conductors are to be furnished with appropriate sweating sockets.

3. **Coolers.**—If water coolers are employed they are to be arranged so as to prevent leakage or condensation from cooler tubes from entering the machines.

4. **Thermometers.**—Machines having an enclosed ventilating system or ducts for the exhaust air are to be fitted with thermometers for recording the temperature of the ventilating air as it leaves the machine.

5. **Ventilation.**—Ample provision is to be made for supplying cool air to and removing hot air from the machine and to avoid as far as practicable any intake of moist or oil-laden atmosphere.

Where the machines are not ventilated by a closed system, using water coolers, they are to be ventilated with cooling air not exceeding 113° F. (45° C.). In cases where the ventilating air exceeds 113° F. the permissible temperature rise of the machine is to be reduced by an amount equal to the excess temperature.

6. **Heating when Idle.**—All generators of 500 kw. or motors of 500 S.H.P. and over, are to be provided with efficient means for heating the windings, either electrically or otherwise, to prevent condensation when idle. If steam pipes are used for this purpose, the joints are not to be within the machine.

7. **Shaft Currents.**—Means are to be taken to prevent the formation of circulating currents which might flow between the shafts and the bearings.

8. **Excitation.**—(*a*) Systems dependent on the auxiliary generators for excitation are to be capable of manœuvring and of maintaining power at all times with a fall of 10 per cent of excitation voltage at the bus-bars.

(*b*) For large equipments an alternative means of excitation is to be provided. The auxiliary generators may constitute this reserve.

9. **Facilities for Inspection and Repair.**—For the purposes of inspection and repair, provision is to be made for the withdrawal and replacement of the field coils of direct current machines and salient pole alternating current machines, and for sufficient access to stator and armature coils. Facilities are to be provided for supporting the motor shaft to permit the withdrawal and inspection of bearing bushes. Wear-down gauges are to be supplied for generators of 1,000 kw., and motors of 1,000 S.H.P., and over.

10. **Mechanical Protection.**—Suitable handrails or screens are to be provided to prevent personal injury or the entrance of extraneous bodies. All live parts in excess of 250 volts direct-current to earth, or 150 volts alternating-current to earth, are to be suitably guarded or enclosed. Machines are to be amply protected against drip and mechanical damage.

11. **Lubrication.**—(*a*) Means of lubrication are to be efficient at all running speeds and all normal working oil temperatures, and with the ship inclined from the normal at any angle up to 15° transversely and 10° longitudinally, and with rolling up to 22½° from the vertical without the spilling of oil.

(*b*) Oil flingers or other suitable means are to be provided to prevent the lubricant from creeping along the shaft or otherwise gaining access to the insulation of the machine or any live part thereof.

(*c*) Every self-lubricated sleeve bearing is to be provided with a suitable overflow which, while permitting efficient lubrication when the machine is running, is to prevent the bearing from containing an excess of oil. Every self-lubricated bearing is to be fitted with an inspection lid and means for visual indication of the oil level. Where forced lubrication is employed, an alternative means of lubrication, such as oil rings or an oil reservoir, is to be provided if no warning device is fitted, or a period of 30 seconds elapses before the machine comes to rest after the interruption of the oil supply.

The lubrication of propulsion motor bearings is to be effective at trailing speeds under all conditions of oil temperature.

12. **Position in Ship.**—(*a*) The machines are to be placed in well-ventilated compartments in which inflammable gases cannot accumulate, and in such a position as to be clear of all inflammable material. Unprotected woodwork or other combustible material is not to be fitted within a distance of 12 inches measured horizontally from, or within 4 feet measured vertically above the machines.

(*b*) The machines are to be placed in positions in which they are not exposed to risk of mechanical injury or to damage from water, steam or oil, and in all ships engaged on open sea service they are preferably to be placed with their axes of rotation in a fore and aft direction. If placed athwartships end play is to be reduced to a minimum and provision made for the end thrust due to rolling of the ship.

(*c*) Ventilation ducts are to be so arranged that water or extraneous bodies cannot drop into the machines.

13. **Foundations and Bilges.**—Plans of the seatings for the main propulsion generators and motors, are to be submitted for approval.

For prevention of accumulation of bilge water *see* **Rules for Pumping and Piping.**

14. **Manœuvring.**—The torque available for manœuvring is to be reasonably in excess of the trailing action of the propeller to enable the latter to be stopped or reversed in a reasonable time when the vessel is travelling at maximum service speed.

15. **Plant to be Earthed.**—The bed-plates and frames of the machines are to be effectively earthed, and insulation is not to be interposed between the prime movers and the generators.

Section 6.

ALTERNATING CURRENT SYSTEMS.

1. **Limiting Pressures.**—The pressure under normal working conditions, at any part of the system for equipments not exceeding 15,000 S.H.P. per shaft is not to exceed the following values.

Between lines	...	3,500 volts.
To earth ...	...	2,020 volts.

Proposals involving higher voltages for larger equipments are to be submitted for consideration.

2. **Stator Laminations.**—(*a*) Laminations are to be securely clamped, and are to be efficiently and permanently supported around the whole of the periphery.

(*b*) Laminations are to be suitably insulated from one another with an approved durable material.

3. **Propulsion Generators.**—(*a*) The ratings and limits of permissible temperature rise for alternators are to conform to Appendix 4. If the ventilating air exceeds 113° F. (45° C.) the permissible temperature rise is to be reduced by an amount equal to the excess temperature.

Where sea water cooling is used the temperature rises specified in Appendix 4 may be increased by 18° F. (10° C.) provided that the maximum temperature of the air entering the machine does not exceed 104° F. (40° C.) when using sea water at 85° F. (29·5° C.).

(*b*) Machines of 5,000 k.v.a. and over, or machines having an axial core length of one metre or over, are to have at least three embedded temperature detectors and a temperature indicating instrument. Detectors of this type should be fitted to smaller machines where practicable.

(*c*) Suitable space is to be provided for the removal of the rotor for the inspection of the rotor and stator.

(*d*) Stator and rotor windings are to be suitable for manœuvring in accordance with **clause 6** (*b*) of this Section without impairment.

4. **Propulsion Motors.**—(*a*) The ratings and limits of permissible temperature rise for motors are to conform to Appendix 4.

Where the temperature of the cooling air exceeds 113° F. (45° C.) the permissible temperature rise is to be reduced by an amount equal to the excess temperature.

Where sea water cooling is used the temperature rises specified in Appendix 4 may be increased by 18° F. (10° C.) provided that the maximum temperature of the air entering the machine does not exceed 104° F. (40° C.) when using sea water at 85° F. (29·5° C.)

(*b*) The collector rings and rotor terminals of synchronous type motors are to be suitably insulated for the voltage induced during manœuvring. Insulating barriers are to be provided where necessary.

(*c*) Induction rotor windings of synchronous type motors, used for manœuvring purposes, are to be mechanically strong and of ample section to prevent over-heating during repeated manœuvres in accordance with **clause 6** (*b*) of this Section.

(*d*) Provision is to be made for machining the collector rings or for their easy removal for that purpose.

(*e*) Machines of 5,000 S.H.P. and over, or machines having an axial core length of one metre or over, are to have at least three embedded temperature detectors and a temperature indicating instrument. Detectors of this type should be fitted to smaller machines where practicable.

5. **Stability.**—The motors and generators are to be designed and arranged to maintain electrical stability and to remain in step under all normal conditions of running.

6. **Excitation.**—(*a*) Exciters, balancers, boosters and motors for driving them are to conform to Appendix 3, except that for all ocean-going ships and ships operating in tropical waters the temperature rise, measured by thermometer at the rated load, is not to exceed the limit shown in the following schedule :—

	Temperature Rise.	
	Class A Insulation.	Class B Insulation.
Windings (other than single-layer field windings with exposed surfaces) and cores with which they are in contact	63° F. (35° C.)	81° F. (45° C.)
Single-layer field windings with exposed surfaces	81° F. (45° C.)	108° F. (60° C.)
Commutators ...	72° F. (40° C.)	72° F. (40° C.)

Where the ventilating air adjacent to the machine exceeds 113° F. (45° C.) the permissible temperature rise of the machines is to be reduced by an amount equal to the excess temperature.

(*b*) After a full load run of the complete equipment, for not less than three hours, followed by a full speed reversal and five normal manœuvres within a period of 30 minutes, the temperature rise of any machine supplying the extra excitation required for alternating current systems, is not to exceed that permitted in the preceding clause by 18° F. (10° C.).

Ample margin in the temperature rise of machines is to be allowed for inadvertent delay in the operations of manœuvring referred to above.

(*c*) Field windings and all machines supplying over-excitation during manœuvring are to be capable of withstanding the excess current over a reasonable period, to allow for inadvertent delay during a reversal operation, without impairment, after attaining the temperature rise corresponding to normal continuous working.

(*d*) Negative boosters are, when necessary, to be provided with overspeed protection.

(*e*) The strength of shafts and couplings of exciting machines for alternating current equipments is to be suitable for the increased output necessary during manœuvring.

Section 7.

DIRECT CURRENT SYSTEMS.

1. **Limiting Pressures.**—For equipments not exceeding 15,000 S.H.P. per shaft the pressure to earth at any part of the system under normal working conditions is not to exceed 600 volts. The voltage of any single armature is not to exceed 1,000.

Proposals involving higher voltages for larger equipments are to be submitted for consideration.

2. **Propulsion Generators and Motors.**—The ratings and limits of permissible temperature rise are to conform to Appendix 4.

Where the temperature of the cooling air exceeds 113° F. (45° C.) the permissible temperature rise is to be reduced by an amount equal to the excess temperature.

3. **Brush Gear.**—The brushes are to be staggered longitudinally to prevent the formation of ridges on the commutators and arranged in such manner that in multipolar machines every part of the commutator working surface is swept by an equal number of positive and negative brushes.

Brush gear is to be mounted on the frame or bed-plate of pedestal-bearing machines having an output of 150 kw. per 1,000 revolutions per minute and above.

4. **Excitation.**—The arrangements for motor and generator excitation are to be such that if the motor excitation circuit is opened by a switch or contactor the generator excitation is simultaneously opened or the generator voltage is immediately reduced to zero.

5. **Overspeed Protection.** — Overspeed protection devices are to be arranged to interrupt the supply of power, and the armatures are to be suitably constructed to prevent damage due to temporary overspeeding, where the system permits excessive overspeeding at light loads.

Section 8.

GENERAL REQUIREMENTS FOR PROPULSION CONTROL GEAR AND SWITCHBOARDS.

1. **Position.**—(*a*) Control boards and switchboards are to be placed in accessible, well-ventilated positions, free from inflammable gases and acid fumes, and in which they are not exposed to risk of mechanical injury or damage from water, steam or oil.

(*b*) Unprotected woodwork or other combustible material is not to be fitted within a distance of 12 inches measured horizontally from, or four feet measured vertically above, any live metal.

(*c*) Essential controls for manœuvring operations are to be grouped at the starting platform and any necessary instruments and gauges are to be in direct view from this position.

2. **General Construction.**—(*a*) Switchboards and control panels are to be constructed wholly of durable, non-ignitable, non-absorbent materials.

(*b*) If insulating material be used for the base, it is to be of permanently high dielectric strength and insulation resistance, and full particulars regarding its properties should be submitted for consideration.

Where used for panels such materials are to be coated with insulating varnish or enamel over their entire surface including such parts as have been exposed by drilling or other machining operations.

(*c*) If semi-insulating materials such as marble or slate are used, all conducting parts are to be insulated from the slate or marble slab with mica or other approved non-hygroscopic insulating material, and the slab is to be similarly insulated as a whole from the frame on which it is mounted; the frame is to be effectually earthed.

(*d*) The various live parts are to be so arranged, by suitable spacing or shielding with non-ignitable insulating materials, that an arc cannot be maintained between any such parts, or between such parts and earth.

(*e*) All parts, including connections, are to be readily accessible from the front or back. Fuses are to be placed in approved positions.

(*f*) Omnibus bars and ordinary bare connecting conductors on switchboards are to be proportioned so that their average temperature will not rise more than 54° F. (30° C.) above that of the surrounding air when rated at 2,000 amperes or below when the maximum current flows through them continuously. For bare conductors rated above 2,000 amperes the temperature rise is not to exceed 72° F. (40° C.). The temperature rise of each part is not to exceed the average temperature by more than 9° F. (5° C.) and in other respects they are to comply with Appendix 1. Aluminium is not to be used.

(*g*) All cable connections in the control and switchgear in any circuit essential for manœuvring or maintenance of propelling power are to be stranded and to consist of not less than seven strands and have a sectional area of not less than ·0045 square inches (7/·029).

(*h*) All nuts and screws securing electrical connections are to be effectively locked so that they cannot become loose.

(*i*) All circuits, instruments and important apparatus are to be clearly and indelibly labelled for indentification. If detachable name plates are employed, they are to be non-ignitable, and if of metal are to be disposed so as not to involve risk of short circuits or earths.

(*j*) Each voltmeter, wattmeter, voltage coil and pilot or earth lamp with its connecting wires is to be protected individually by a fuse on each insulated pole close to the source of supply. Potential transformers for instruments, relays, etc., may be protected by fuses on the primary side only.

Pilot lamps and indicating lamps may have common fuses.

(*k*) Switches and contactors are as far as practicable to be connected so that their blades or moving parts are not alive in the "off" or de-energised position.

(*l*) Where switches and fuses are fitted on the same pole they are to be arranged so that the fuses are not alive when the corresponding switches are in the "off" position.

(*m*) Switches and circuit breakers are to conform to the **Rules for Electrical Equipment, Section 3, clause 19.**

(*n*) Fusible cut-outs are to comply with the **Rules for Electrical Equipment, Section 3, clause 20,** and are to be suitably labelled with the circuits or devices which they control.

(*o*) All levers, handles, handwheels, interlocks, and their connecting links, shafts and bearings for the operation of switches and contactors are to be of such proportions that they cannot be broken by manual operation.

(*p*) Suitable interlocks, preferably mechanical, are to be provided to prevent damage by improper operation, such as the opening of switches or contactors not intended to be operated while carrying current.

(*q*) Provision is to be made for the manual operation of all manœuvring contactors, switches, field regulators, or controllers with reasonable effort, without the aid of solenoids or other electric, pneumatic or hydraulic aid. If such aid be used for normal operation, failure of the electric, pneumatic or hydraulic aid must not result in interruption of power to the screw shaft and the device must be capable of purely manual operation without any delay in changing over to manual control.

NOTE:—This requirement does not apply to bridge control.

(*r*) Where voltage coils are used for relays or for retaining purposes, the coils and resistances in series with them, if any, are to be of substantial and reliable construction where failure of such coils would result in the interruption of the supply of power to the propeller shaft. The number of such coils in a propelling system and the number of auxiliary contacts in series with them is to be reduced to a minimum.

(*s*) The cases of all instruments using a higher pressure than 250 volts direct-current to earth or 150 volts alternating current to earth, and secondary windings of all instrument transformers, are to be earthed.

(*t*) Switches normally subject to arcing, such as the short circuiting and isolating switches for direct current generators connected in series, are to be provided with substantial and renewable arcing tips.

(*u*) All apparatus is to be arranged to function satisfactorily under conditions of vibration and shock, and with the ship inclined from the normal at any angle up to 15° transversely and 10° longitudinally, and when rolling up to $22\frac{1}{2}^{\circ}$ from the vertical.

(*v*) Shunt-operated contactors, releases, and relays are to be capable of functioning satisfactorily even when the line voltage falls to 80 per cent and 85 per cent for direct current circuits and alternating current circuits respectively, with the coils at the temperature which they will attain under normal service at the normal line voltage, and, in the case of alternating current circuits, at rated frequency.

(*w*) For the purpose of maintaining alignment and ease of operation, operating shafts are to be fitted with flexible couplings and expansion joints where necessary and means are to be provided for effective lubrication.

(*x*) All steel parts, including springs, are to be suitably treated to resist corrosion.

3. **Overload and Short Circuit Protection.**—Provision is to be made for protection against severe overloads or electrical faults likely to result in serious injury to the plant, but the operating point is to be set sufficiently above the currents and loads usually experienced in a heavy sea-way or when manœuvring, to prevent interruption of power.

4. **Earth Detection.**—(*a*) The main propelling circuit is to be provided with means for detecting earth faults.

(*b*) For D.C. equipments exceeding 500 volts and for all A.C. equipments, aural and visual alarms are to be operated, but power supply is not to be interrupted on the occurrence of a fault, so that the plant may continue to operate with

a single earth. If an earth connection be used for the operation of the detector, the arrangements are to be such that the earth circuit is automatically opened in order to stop the circulation of fault current.

(*c*) Earth detection devices are to be arranged to function for all earth leakage faults exceeding five amperes. On three-phase alternating current systems at least 95 per cent of the generator and motor windings are to be protected.

(*d*) A switch may be installed to cut out the aural device to prevent continuous alarm, but in such case the visual device is to be automatically switched on when the aural device is switched off.

(*e*) Excitation circuits are to be provided with lamps, voltmeters or other suitable means to indicate continuously the state of the insulation of the system under running conditions.

5. **Mechanical Protection.**—All exposed current-carrying parts having a potential of over 250 volts direct-current to earth or 150 volts alternating-current to earth are to conform to the following requirements :—

(*a*) Terminals are to be enclosed.

(*b*) The sides and rear of switchboards and control panels are to be suitably screened.

(*c*) Access doors are to have prominent and permanent nameplates giving the maximum voltage, and are to be interlocked to prevent access while such parts are alive, or in approved cases are to be provided with a special key under the care of the chief engineer.

(*d*) Exposed current carrying parts exceeding 250 volts to earth are not to be permitted on any switchboard or control panel.

6. **Bridge or Deck Control.**—(*a*) The control is to be simple and easy to operate.

(*b*) It is to be such that the operator cannot produce currents or loads in excess of the working capacity for which the plant is designed.

(*c*) Control is to be carried out without reference to electrical instruments.

(*d*) Alternative control in the engine room is to be provided, and so arranged that transfer of control to the engine room can be made in emergency without excessive loss of time.

(*e*) It is to be arranged so that simultaneous control of the propelling machinery from the bridge and engine room is not possible.

7. **Instruments and Gauges.**—(*a*) Instruments and gauges which are necessary for the efficient operation of the plant are to be provided. Particulars are to be submitted for consideration. In cases where the rotation of the propeller motors cannot readily be observed from the starting platform, indicators are to be provided.

(*b*) All essential instruments are to be capable of withstanding vibration and shock without impairment and are to be fitted in moisture-proof cases.

(*c*) Instruments are where necessary to be protected from the influence of stray magnetic fields.

(*d*) A 500-volt insulation tester, giving the resistance in megohms, for the purpose of testing and tracing faults is to be carried on all sea-going ships.

8. **Discharge Protection.**—(*a*) For the protection of the field windings and cables efficient means are to be provided for limiting the induced voltage when the field circuits are opened.

(*b*) Where excitation is obtained from the auxiliary bus-bars efficient means are to be provided to limit the induced voltage on the bus-bars when the generator or distribution circuit breaker opens.

9. **Direct-current Systems.**—(*a*) Where two or more direct-current generators are connected in series, means are to be provided to prevent the reversal of the prime mover on the failure of the power supply to any one generator if such reversal would result in damage or overspeeding.

(*b*) If the regenerated energy transmitted by the propeller motor on stopping or reversing the propeller is of a magnitude that would cause an undue increase in the engine speed, means are to be provided for suitably absorbing or limiting such power.

(*c*) Where the propulsion generators are also to be used for other purposes, suitable overload protection and provision for voltage adjustment is to be made in conformity with the **Rules for Electrical Equipment.**

10. **Reversing Switches.**—(*a*) Contactors or switches used for reversing the rotation of the propeller, are to be mechanically interlocked to prevent the circuits for ahead and astern rotation being closed simultaneously.

(*b*) The reversing contactors or switches are also to be provided with means for forcing them open if they should become stuck in the closed position.

11. **Resistances.**—(*a*) Resistances are to comply with **Section 13, clauses 2** (*d*) and **3,** of the **Rules for Electrical Equipment.**

(*b*) Shunt resistances connected across the field circuit of synchronous propelling motors when they are functioning as induction motors are to be suitably insulated for the voltage induced when reversing and amply rated to allow for inadvertent delay during the reversing operation.

12. **Temperature Alarm.**—Machines having an enclosed ventilating system or ducts for the exhaust air, are to have an aural alarm device arranged to operate when the outgoing air exceeds the predetermined safe value.

13. **Reversing Levers and Handwheels.**—Propeller reversing levers or handwheels are to be clearly and permanently marked with the positions for "ahead" and "astern" working. Levers or handwheels placed athwartships are to be arranged for right hand or clockwise rotation for ahead working or if operated in a fore and aft direction to be arranged to correspond with the direction in which the ship is moving.

14. **Auxiliary Power.**—Distribution circuits connected to the auxiliary bus-bars for excitation and lubricating oil pumps, etc., are to be suitably protected from interruption due to overloading of non-essential circuits.

15. **Speed Control.**—In multiple-propeller ships where the propeller speed is arranged to be varied by voltage control or other electrical method, means are to be provided to permit an adjustment between 50 per cent and 100 per cent of maximum rated speeds in a suitable number of steps.

Section 9.

CONDUCTORS AND CABLES.

1. **Conductors.**—(*a*) All conductors are to be of annealed copper conforming to the Standards of the International Electrotechnical Commission Publication No. 28.

(*b*) Where the insulating covering of the conductor contains sulphur, each wire is to be efficiently and uniformly coated with tin free from all impurities.

(*c*) Conductors in any circuit essential for manœuvring or maintenance of propelling power are to be stranded and to consist of not less than seven strands and to have a sectional area not less than ·0045 square inches (7/·029).

(*d*) The size of conductor is to be selected so that the drop in voltage, when carrying rated full load and overloads, is not greater than that allowed for in the design of the machines.

(*e*) The current in any conductor is not to exceed that given in **Tables I.** and **II.** when carrying current continuously or **Table III.** when intermittently loaded. In no case is a shorter rating than one half-hour to be taken. In the case of field discharge circuits, particulars should be submitted for consideration.

Field currents, when the windings are cold, are to be taken into consideration when determining the size of conductors.

(*f*) Where multicore cables are used the dimensions are to be submitted for approval.

(*g*) Bus-bars and connections are to be in accordance with Appendix 1 and, if used for connections to machines, must be rigidly and strongly supported, efficiently insulated and guarded, and protected from drip and jets of liquid or steam. Pipes are not to enter ducts containing such connections. Suitable means are to be arranged for draining any accumulation of moisture in ducts.

2. **Insulation and Protective Covering of Cables.**—(*a*) All cables are to conform to **Section 7** of the **Rules for Electrical Equipment.**

(*b*) For multicore cables the thickness of dielectric on each conductor is to be the same as for the same size of single core cable and the thickness of lead sheathing is to be in accordance with **Tables V., VI., VII.** and **VIII.** The bedding and diameter of wire armouring are to be in accordance with **Table IX.**

(*c*) All cables for pressures exceeding 250 volts direct-current to earth or 150 volts alternating-current to earth are to be lead sheathed and braided. They are also to be armoured or protected in an approved manner. The thickness of dielectric and lead covering is to conform to **Table VII.** (660 volt paper or varnished cambric insulated), **Table VI.** (660 volt rubber insulated) or **Table VIII.** (3,300 volt paper or varnished cambric insulated).

A dielectric test is to be applied to all cables in accordance with the **Rules for Electrical Equipment, Section 7, clause 12.**

3. **Installing and Fixing of Cables.**—(*a*) All cables are to be installed and fixed in conformity with **Section 9** of the **Rules for Electrical Equipment.**

(*b*) Cables are to be run in accessible, well-ventilated positions where they can be easily inspected.

4. **Cables for Alternating Currents.**—(*a*) Where single-core cables are used for alternating-current circuits rated in excess of 5 amperes :—

(i) The armouring, if any, is to be non-magnetic material.

(ii) Magnetic material is not to be used between such cables.

(iii) Such cables are to be so arranged that the inductive effects of the groups are substantially eliminated.

(*b*) Single-core lead-alloy sheathed cables are to have their lead sheaths bonded together and earthed only at approximately the mid-point of the cable run, or alternatively, earthed at both ends, provided that, in the latter instance, the cross-sectional areas of the cables are so increased as to compensate for the increased heating. In addition, such cables are to be carried on insulators to prevent the circulation of currents in the metal sheaths The sheaths of multicore cables are to be earthed at each end and long runs are also to be earthed intermediately.

(*c*) Magnetic material is not to be used between single core cables of a group. Where cables pass through bulkheads or steel panels, all the conductors of the same set are to pass through a non-ferrous plate or gland so that no magnetic material passes between the cables, and the clearance between the cables and magnetic material is to be not less than three inches.

NOTE :—This clause does not apply to cables carrying 10 amperes or less.

(*d*) Single core cables carrying 100 amperes or over are to be fixed not less than three inches from parallel magnetic material.

(*e*) Single core cables are to be so arranged that the inductive effects of the group are practically eliminated.

5. **Cable Sockets.**—Large cable sockets are preferably to be secured by two or more studs or bolts, not exceeding $\frac{3}{4}$ inch diameter, and the nuts securely locked.

6. **Synchronous Motor Cables.**—Cables connected to the collector rings of synchronous motors during manœuvring are to be suitable for the voltage induced during those periods.

7. **Interference with Magnetic Compasses.**—Single-conductor circuits carrying continuous current are to be arranged with lead and return conductors fitted as close to one another as possible. Tests are to be made during the adjustment of the compasses to determine the effect of switching the main circuits on and off and careful records are to be kept of any errors observed, whether corrected or not.

Section 10.

SECONDARY BATTERIES.

1. **General.**—All batteries are to conform to **Section 16** of the **Rules for Electrical Equipment.**

2. **Capacity.**—Batteries used for starting main propulsion engines in lieu of compressed air are to comply with the ollowing :—

(*a*) If used for purposes other than starting, full particulars of the battery should be submitted for consideration.

These particulars should include the capacity which it is estimated will be required to give 12 starts in succession of one main engine, also details of the other uses for which the battery is intended; the facilities for charging should also be indicated.

(*b*) If used solely for starting main engines two batteries are to be fitted each capable of starting one main engine six times in succession without recharging. Details of the charging arrangements are to be submitted for consideration.

(*c*) Plans showing the location and arrangement of battery compartment are to be submitted for approval.

Section 11.

TRIALS.

1. **Works Tests.**—(*a*) The machines, switchgear, main cables and control gear, are to be tested in the presence of the Surveyors at the makers' works so far as practicable to ensure compliance with the requirements relating to temperature rise, dielectric strength, insulation resistance and operating characteristics.

(*b*) The dielectric test to be applied to the control gear is to be equal to the test for that part of the machine to which it is to be connected or otherwise is to be 1,000 volts plus twice the rated voltage of the circuit with a minimum of 2,000 volts between poles and between current-carrying parts and earth ; the test voltage is to be maintained for one minute and is to be made with alternating current at any convenient frequency between 25 and 100 cycles per second.

(*c*) The rotor windings of turbine driven alternators are to be tested for insulation resistance when rotating at maximum rated speed, as well as at standstill.

2. **Ship Trials.**—After installation on board the entire propelling equipment is to be tested under working conditions and operated in the presence of the Surveyors and to their satisfaction.

The insulation resistance of the main windings of each machine in megohms should be not less than

$$\frac{3 \times \text{rated voltage}}{\text{rated k.v.a.} + 1{,}000}$$

The insulation resistance of cables, field windings and control gear when isolated and separated for testing purposes should be not less than one megohm.

All insulation tests are to be made where possible when the machines are hot and with a D.C. voltage of about 500 applied for sufficient time for the indicator to become practically steady.

Section 12.

SPARE GEAR.

Owing to the varied character of equipments an exact list of spares cannot be specified and a list should be submitted for consideration together with or subsequent to the submission of final plans. The following should be included as a minimum for all ships engaged in open-sea service.

1. **For Generators, Motors and Exciters.**

One set of bearing bushes, with oil rings, if used, of each size and type for the propulsion generators, motor and exciter.

Two lines of brush holders of each size and type.

One set of carbon brushes for one generator, exciter, and one motor.

One shunt field coil of each size and kind used for D.C. generators, exciter and motors.

One set of insulation or insulated brush studs for two lines of brushes of each size and type.

In cases where there is no stand-by exciter or alternative means of excitation, spare armatures for the excitation machines may be required.

One set of slip rings for one motor if of the A.C. type

2. **Switch and Control Gear.**

One set of contacts liable to burning or wear.

One set of springs.

Ten per cent of each different resistance element, but at least one of each.

One of each type of shunt wound coil used for contactors, relays, or trip coils.

Two fuse handles of each type and size, or 10 per cent, but not less than 12 of each type of cartridge or other non-rewireable cut-out.

3. **General.**

Special dismantling tools, if any, required for overhauling machines or control gear.

100 yards of control cable.

A suitable quantity of insulating tape and fuse wire.

4. **Storing.**

Electrical spares should be protected against excessive heat, and against moisture and rodents, and should be periodically tested.

71 Fenchurch Street, London, E.C.3.

15th December, 1949.

ELECTRICAL EQUIPMENT.

INDEX

ELECTRICAL EQUIPMENT.

	Section.	Clause.	Page.
Accessories.	10	—	395
„ in tankers	15	9	406
Addition to existing installation ...	1	1(*f*)(*g*)	371
Alternative lighting in engine rooms, etc.	4	9	383
Alternating current—			
single core cables for	6	8	387
Batteries.			
Secondary, ...	16	—	407
„ arrangement	16	3	407
„ construction	16	2	407
„ control	16	8	408
„ for internal communications	18	2	409
„ naked lights	16	7	408
„ position of battery compartment	16	4	407
„ ventilation	16	6	408
Busbars. (**Appendix 1**)	—	—	437
„	3	5	376
Cable ends	9	1	391
„ joints during erection	9	11	394
„ sheath, earthing of	9	5(*f*)	393
Cables, for alternating current	6	8	387
	9	5(*j*)	393
„ armouring	7	10	389
„ at expansion joints	9	16	395
„ bending of	9	4(*c*)	392
„ bunching of	9	5(*i*)	393
„ current rating of	6	5,6	386,387
„ reduction in sectional area ...	6	10	387
„ for contactor coil circuits ...	7	13	390
„ for cargo winches, cranes etc. ...	6	6	387
	Table XIV.		
„ in cold storage chambers ...	9	5(*d*)(*e*)	392
„ fire-resisting type	7	16(*b*)(*c*)	
„ in conduit	9	7	393
„ „ cold storage chambers ...	9	5(*e*)	392
„ „ lift and hoist shafts ...	9	15	395
„ "H.R." type	7	6	388
	7	11	389
„ in machinery spaces, galleys, bathrooms, laundries, etc. ...	9	5(*e*)	392
„ in motor circuits	6	5(*e*)	386
„ „ wood casing	9	8	394
„ installing and fixing of	9	—	391
„ insulation and protective covering of	7	—	387
„ intermittently loaded	6	5(*d*)	386
	Table III.		
„ lead-alloy sheathings for ...	7	9	389
„ maximum temperatures for ...	Appendix 9		447
„ mineral-insulated copper-sheathed	9	17	395
	Table XI A.		
„ multicore	7	12	390
„ paper insulated	7	1,5	388,389
„ „ „ current ratings of	6	5	386
	Tables II., II A. & III.		
„ „ „ sealing of ...	9	3	391
„ passing through bulkheads etc.	9	13	395
„ selection of runs	9	4	392
Cables, separation of communication from power	18	4	409
„ spacings of clips and cleats for	9	6	393
	Table XI.		
„ support and protection	9	5	392
„ types of	7	1,2	387,388
„ twin- and three-core	7	3	388
„ varnished cambric insulated ...	7	7	389
„ „ „ „ current ratings of	6	5	386
	Tables II., II A. & III.		
„ „ „ „ sealing of	9	3	391
„ „ „ „ maximum temperatures for	Appendix 9		447
„ vulcanized rubber insulated ...	7	4	388
„ „ „ „ current ratings of	6	5	386
	Tables I., I A. & III.		386
„ „ „ „ sealing of	9	3(*c*)	392
„ „ „ „ maximum temperatures for	Appendix 9		447
Ceiling roses, construction of	10	5	397
Circuit, final sub-, arrangement of ...	5	—	385
„ „ „ control of	5	4	386
„ „ „ diversity factor not to be applied ...	6	5(*b*)	386
„ „ „ protection of ...	5	2	385
Circuit breakers, adjustment relative to size of conductor ...	3	19(*f*)	380
	6	10	387
„ construction and arrangement of ...	3	19	379
„ non-linked, prohibited in certain conductors	3	11	378
	4	3(*c*)	382
„ use of	3	18	379
Circuits, final sub-, separation of lighting from heating	5	3	386
Cleated wiring, installing of	9	6	393
Communication Circuits, apparatus for	18	3	409
„ „ batteries for ...	18	2	409
„ „ cables for ...	7	8	389
	18	4	409
„ „ identification of	18	6	409
„ „ machines for ...	18	1	409
„ „ protection of	18	5	409
Communications, internal	18	—	409
Compass, magnetic, interference with ...	4	12	383
Conductor minimum size of	6	4	386
Conductors	6	—	386
„ current rating relative to adjustment of circuit breakers	3	19(*f*)	380
„ material of	6	2	386
„ size of, and voltage drop ...	6	9	387
Conduit, Cables in	9	5(*b*)(*c*)	392
		7	393
		9	394
		10	394
		14	395
Constant Current Series System ...	20	—	410
Control Gear	13	—	400
„ „ assessment of motor currents for	13		402

	Section.	Clause.	Page
Control gear, for motors	13	7	402
	23	11	413
„ „ general construction of ...	13	1	400
„ „ position in ship	13	6	402
„ „ resistors for	13	3	402
„ „ temperature limits for ...	13	2	401
	Table XV.		
„ „ terminals for	13	5	402
„ „ voltage range	13	4	402
Cooking Appliances, ...	14	—	403
„ „ protection of inflammable materials	14	5	403
„ „ construction of ...	14	1	403
„ „ control of ...	14	3	403
„ „ earthing of ...	14	2	403
„ „ in tankers ...	15	13	406
„ „ portable	14	4	403
„ „ limiting pressures	1	3	371
Couplings, Electro-Magnetic	21	—	410
Critical Speed of Generating Set ...	2	1	372
Distribution	4	—	381
„ fuse-board, connection of ...	4	1	381
„ „ construction of	3	21	381
„ „ in tankers ...	15	4(*b*)	404
„ in tankers	15	5	405
Diversity Factor	6	5(*b*)	386
	6	6	387
Earth Continuity Conductor in Flexible Cord	8	5	391
	10	2(*e*)	396
	15	6(*d*)	405
„ return	4	4	382
„ indicating	3	15	379
	15	4(*d*)	405
Earthing Connections	4	6	382
„ of cable sheath	9	5(*f*)	393
„ „ instrument cases and transformers ...	3	4	376
„ „ neutral	4	5	382
„ „ switchboards	3	4	376
„ screws	4	6(*c*)	383
Emergency Generating Sets, position in ship	2	18	374
governor for turbine driven generators	2	1(*b*)	372
„ supply	4	10	383
„ switchboard, instruments on	3	13	378
„ „ switchgear for each generator	3	9	376
„ „ „ for each outgoing circuit ...	3	10	377
Equalizer Connections for Generators	2	5(*a*)	372
	6	7	387
Essential Services, protection of ...	3	16	379
Expansion joints, cables over	9	16	395
Exposed wiring, installing of	9	6	393
Fans, cabin, in tankers	15	2	404
	15	14	407
Final sub-circuits—control of ...	5	4	386
Fittings, Lighting	10	—	395
„ lighting in tankers	15	9	406
Flameproof fittings in tankers ...	15	1	404
	15	10	406
	15	15	407
	15	16	407
	Appendix 6		

	Section.	Clause.	Page.
Flexible Cable, earth continuity conductor in	8	5	391
	15	6(*d*)	405
„ „ construction of ...	8	—	391
„ „ current rating of ...	8	4	391
	Table IV.		
„ „ prohibited for fixed wiring	9	5(*h*)	393
Fluorescent lamps	10	7	397
Fuse and conductor, relative current ratings of	3	20(*d*)	381
	6	10	387
„ cartridge, indicating type in tankers	15	9(*e*)	406
„ maximum size of	3	20(*d*)	381
„ minimum „	5	2(*c*)	385
„ elements	Table XII.		
Fuses, approval of	3	20(*b*)	380
	Appendix 5		
„ category of, in relation to generator capacity	3	20(*a*)	380
„ labelling of	3	20(*c*)	381
„ construction and arrangement of	3	20	380
„ in socket outlets and ceiling roses	3	20(*h*)	381
„ in tankers	15	9(*e*)(*f*)	406
Generating Plant	2	—	372
„ „ emergency sets ...	2	20	375
„ „ for tankers ...	15	3	404
„ „ lubrication of ...	2	14	374
	2	20	375
„ „ position in ship ...	2	18	374
„ „ shaft currents in ...	2	16	374
„ „ spare plant ...	2	17	374
Generators, adjustment of compounding	2	5(*c*)	372
„ alternating current ...	2	7	373
„ characteristics of	2	5	372
„ clearance from oil vents ...	2	21	372
„ construction of	2	10	373
„ equalizer connections for ...	2	5(*a*)	372
	6	7	387
„ excessive ambient temperature	2	4	372
„ field regulators for ...	2	6	373
„ for battery charging ...	2	5(*e*)	373
„ mechanical balance ...	2	13	374
„ performance	2	2	372
„ rating plate	2	8	373
„ switchgear	3	9	376
„ temperature rise	2	2	372
„ testing of	2	5(*b*)	372
	2	9	373
„ voltage regulations of ...	2	5	372
„ welding on shafts	2	10(*c*)	373
Heaters, space, construction of	14	6	404
Heating Appliances and explosion risks	14	7	404
„ „ protection of inflammable material	14	5	403
„ „ construction of ...	14	1	403
„ „ control of ...	14	3	403
„ „ earthing of ...	14	2	403
„ „ in tankers ...	15	13	406
„ „ portable	14	4	403
Inspection and draw boxes	9	10	394
Installing and fixing of cables ...	9	—	391
	15	7	406
Instrument scales	3	14	378
Instruments to be provided on switchboards	3	13	378
Insulation of the system, indication of	3	15	379
	15	4(*d*)	405
„ material for switchboards ...	3	2	375

	Section.	Clause.	Page.
Interference with magnetic compass	4	12	383
Intermittently loaded cables	6	5(*d*)	386
	6	6	387
	Table III.		
Isolating link, provision of	3	12	378
	4	3(*c*)	382
Joint Boxes, construction of	3	22	381
Joints in cables during erection ...	9	11	394
Junction boxes, construction of ...	3	22	381
Lampholders	10	3	397
Lamps	11	—	398
	15	10	406
Lead-alloy sheathings for cables ...	7	9	389
	15	6	405
Lift, electric, circuits	4	14	384
„ cables in lift shafts	9	15	395
Lighting, alternative circuit in engine rooms, etc.	4	9	383
Lightning Conductors	19	—	409
Lights, navigation	4	13	384
„ „ alternative circuit for	4	13(*d*)	384
„ „ lamps for	11	3	398
„ „ automatic indicator...	4	13(*c*)	384
Link, isolating, provision for	3	12	378
	4	3(*c*)	382
Lubrication of generators	2	14	374
	2	20	375
„ „ motors	12	9	400
Luminous discharge tubes	17	—	408
Main Switchboard, instruments on ...	3	13	378
„ „ switchgear for generators ...	3	9	376
„ „ „ outgoing circuits	3	10	377
Mechanical balance of generators ...	2	13	374
„ „ motors ...	12	8	400
Motor Control Gear	13	—	400
„ circuits, protection of	13	8	402
Motors	12	—	398
„ construction of	12	5	399
„ earthing of	12	10	400
„ excessive ambient temperature ...	12	3	399
„ lubrication of	12	9	400
„ in tankers	15	16	407
„ performance of	12	1	398
	Appendix 3		
„ position in ship	12	12	400
„ temperature rise for	12	1	398
	12	2	399
	Tables XVI. & XVII.		
„ testing of	12	4	399
„ terminals for	12	7	400
Navigation Lights (*see* Lights, navigation)			
Neutral, earthing of	4	5	382
Oil Fuel Pumps, Control of	4	16	385
Over-current protective devices, types of	3	18	379
Plugs and Socket Outlets	10	6	397
Protection against excess current ...	3	17	379
	3	19(*f*)	380
	3	20(*d*)	381
	4	2	382
	4	3	382
	5	2	385
Protection of essential services	3	16	379
	3	17	379
„ final sub-circuits ...	5	2	385
Pump rooms, cargo, lamps and wiring in	15	15	407
Radio interference suppression, components for	22	—	411
Resistors, construction of	13	3	402
Searchlight lamps	11	2	398
„ „ in tankers	15	11(*b*)	406
Section Boards, construction of ...	3	21	381
Shore connections	4	11	383
Socket-outlets, construction of ...	10	6	397
Space heaters	14	6	404
Spacing of clips and cleats	9	6	393
	Tables XI. XI A.		
Spare gear	24	—	413
Steering gear circuits	4	15	385
Switchboards and inclination of the ship	3	8	376
Switchboards and Switchgear ...	3	—	375
„ earthing of frame ...	3	4	376
„ for tankers	15	4	404
„ instruments to be provided on	3	13	378
„ position of	3	1	375
„ single pole switches and fuses on	3	3(*i*)	376
„ switches on, in relation to fuses	3	3(*h*)	376
Switches, construction and fixing of ...	3	19	379
	10	4	397
„ non-linked prohibition in certain conductors ...	3	11	378
	4	3(*c*)	382
Switchgear for generators	3	9	376
„ „ outgoing circuits ...	3	10	377
Tankers, special requirements for ...	15	—	404
„ cabin fans on	15	14	407
„ cables on	15	6	405
„ cargo pump rooms on	15	15	407
„ cooking appliances on	15	13	406
„ distribution on	15	5	405
„ earth-indicating devices for ...	15	4(*d*)	405
„ fittings on	15	9	406
„ fuses on	15	9(*e*)	406
„ generating plant for	15	3	404
„ heating appliances on	15	13	406
„ installation of cables on ...	15	7	406
„ motors on	15	16	407
„ notices prohibiting portable appliances on	15	15(*c*)	407
„ nature of supply on	15	2	404
„ prohibition of earthing on ...	15	5	405
„ portable appliances on ...	15	12	406
„ „ lamps	15	15(*b*)	407
Temperature limits for coils of control gear	Table XV.		433
Three-wire circuits above 250 volts ...	4	8	383
	9	14	395
Two-wire „ „ ...	4	7	383
	9	14	395
Transformers for power and lighting ...	4	17	385
Voltage drop and size of conductors ...	6	10	387
„ „ for radio apparatus mains	6	10	387
„ „ in cables in oil ships ...	15	8	406
Voltages exceeding 250 volts	9	14	395
„ limiting	1	3	372
Watertight accessories, test for ...	10	1(*e*)	396
Watertight glands and deck tubes ...	9	12	395
Windlass motors, cables for	6	6	387
Wood casing, cables in	9	8	394

RULES FOR ELECTRICAL EQUIPMENT.

(For purposes other than Electric Propulsion.)

(For Tables, see pages 416-436.)

Section 1.

GENERAL.

1.—In cases in which electricity is used on board classed ships for purposes other than electric propulsion, the following Rules are to be observed.

(*a*) The equipment and installation are to be inspected and tested by the Surveyors.

(*b*) In order to facilitate inspection, an arrangement plan and circuit diagram of the switchboard, also diagrams of the wiring system showing cable sizes, type of dielectric, and normal working current in the circuits are to be submitted in triplicate for approval. The plans are to state the insulating material used for the switchboard panels, the materials used for insulating bushes, if any, and the capacity, type and make of fuses.

(*c*) All conductors, switchgear, and accessories, are to be of such size as to be capable of carrying, without their respective ratings being exceeded, the maximum current which can normally flow through them.

(*d*) Any novelty in construction, materials or design not specifically dealt with in these Rules is to be reported to the Committee.

(*e*) In special cases the Committee are prepared, at the request of the Owners, to accept installations which, whilst not precisely in accordance with the detailed requirements of the Society's Rules, comply either wholly or in part with a Code of Regulations officially recognised by the Law of the Country in which the ship is owned, provided such Code or appropriate section thereof governing the equipment is considered to be equivalent to the Society's Rules.

In such cases the requirements with regard to inspection and testing and the submission of plans are to be carried out in accordance with the requirements of the Society's Rules.

(*f*) An addition, temporary or permanent, is not to be made to the authorized load of an existing installation until it has been definitely ascertained that the current-carrying capacity and the condition of the existing accessories, conductors, switchgear, etc., affected are adequate for the increased load.

(*g*) Alterations and additions to the installation are to be carried out under the inspection, and to the satisfaction, of the Surveyors, and in accordance with the latest requirements of the Rules. If the alterations are extensive, plans are to be submitted for approval.

2. **Standard Systems.**—The following systems of distribution may be used :—

A. Parallel systems with constant pressure.
   - (*a*) Single wire with hull return.
   - (*b*) Two-wire with direct or single-phase alternating current.
   - (*c*) Three-wire with direct current.
   - (*d*) Three-phase three-wire.
   - (*e*) Three-phase four-wire.

B. Series systems with constant current (direct current only).

3. **Limiting Pressures.**—The pressure of supply is not to exceed the following values :—

A. With direct-current constant-pressure systems :—
   - (*a*) For power, 500 volts.
   - (*b*) For lighting and heating, 250 volts.

B. With alternating-current systems :—
   - (*a*) For power, single-phase, 250 volts.
   - (*b*) For power, three-phase, 440 volts.
   - (*c*) For heating and cooking if permanently connected to fixed wiring, 250 volts.
   - (*d*) For lighting and socket outlets, 150 volts to earth.

C. With constant-current series systems (direct current only) :—650 volts.

For ships carrying oil having a flash point less than 150° F. (65·5° C.)—*See* Section 15.

Section 2.

GENERATING PLANT.

1. **Prime Movers.**—(*a*) Prime Movers are to be fitted with governors which, with fixed setting are to control the speed within the following limits:—

10 per cent momentary variation and 6 per cent permanent variation in speed when full load is suddenly taken off or put on.

(*b*) Where a turbine-driven direct-current generator is arranged to run in parallel with other generators, a switch is to be fitted on each turbine emergency governor to open the generator circuit-breaker when the emergency governor functions. The contacts of the overspeed switch are to be normally closed.

(*c*) The normal running speed of a combined generating set is not to be in the vicinity of a torsional critical speed.

2. **Rating of Generators, etc.**—(*a*) Generators, exciters, balancers, and boosters are to conform to Appendix No. 3.

(*b*) The temperature rise of generators, exciters, balancers and boosters, except pipe-ventilated or water-cooled machines, in all ocean-going ships and ships operating in tropical waters measured in accordance with Appendix No. 3 and under working conditions is not to exceed the limits shown in **Table XVI.**

For pipe-ventilated machines taking cooling air from outside the engine-room where the normal temperature of the cooling air under service conditions will not exceed 104° F. (40° C.) the temperature rise is not to exceed the limits shown in **Table XVII.**

For totally enclosed water-cooled machines with coolers using sea-water at a maximum temperature of 85° F. (29·5° C.) the temperature rise and maximum temperatures are not to exceed those shown in **Table XVII.**

(*c*) The temperature rise of generators, etc., in ships such as coasters, ferries and harbour craft intended solely for use in Northern and Southern waters outside the tropical belt are not to exceed the limits shown in **Table XVII.**

3. **Flameproof Generators.**—Are to conform to Appendix **No. 6.**

4. **Excessive Ambient Temperature.**—Where the temperature of the cooling air exceeds 113° F. (45° C.) in the case of machines where **Table XVI** applies and 104° F. (40° C.) where **Table XVII** applies the permissible temperature rise of the machines is to be reduced by an amount equal to the excess temperature.

5. **Direct-Current Generator Characteristics.**—(*a*) Generators other than those referred to in clause (*e*) below are to be cumulatively compound wound, except that where parallel-connected generators are installed so far apart as to render excessive the amount of copper in the equalizing conductors, the generators may be shunt wound or compound wound with shunt characteristics. The series field windings are to be connected to the negative terminals of the generators.

(*b*) When tested with their prime movers, or when tested separately and the speed regulation of the prime mover is known, unless otherwise specified, generators are to be flat compounded with the shunt field windings self-excited and without alteration to the initial (normal voltage) adjustment of the shunt-field regulators. Where a generator is tested separately and the speed regulation of the prime mover is not known, the permanent increase in speed when the rated load is thrown off is to be taken as 4 per cent of the full load speed, but the generator is to be arranged so that, if required, it can be flat compounded with a permanent increase in speed of 6 per cent.

(*c*) Adjustment of compounding (if required) is to be effected before the acceptance test at the maker's works. For generators larger than 400 kw. per 1,000 revolutions per minute this adjustment is to be made by means of diverters, the generator brushes being in the neutral position. For smaller generators this adjustment may, if desired, be made by movement of the brush position, provided that such movement is not to effect an alteration in the voltage of more than 2 per cent of the rated voltage.

(*d*) Where a generator with shunt characteristics is arranged for parallel running with other generators, and is tested with its prime mover (the shunt field winding being self-excited) and with a fixed setting of the shunt field regulator (*see* clause 6), the no-load voltage is not to be exceeded at any load, and the no-load voltage is not to exceed the full-load voltage by more than 15 per cent. The requirements of this clause do not preclude the use of compounding for the purpose of obtaining the correct generator characteristics.

(*e*) Generators used for charging secondary batteries without the use of regulating resistors in series with the batteries are either to be shunt wound, or to be compound wound and provided with switches to cut out the series windings.

(*f*) Generators driven direct from the screwshaft or the main engines are to be provided with suitable means for automatically maintaining a constant voltage at the distribution busbars.

(*g*) Diverters are not to be connected across commutating pole windings.

6. **Field Regulation for Direct-Current Generators.**—Means are to be provided at the switchboard to enable the voltage of each generator to be adjusted separately. The equipment provided is to be capable of adjusting the voltage of the generator to within 0·5 per cent of the rated voltage for machines above 100 kw. and 1 per cent of the rated voltage for smaller machines at all loads between no-load and full-load, with the generator coupled to its prime mover, at any permissible temperature within the working range. At the conclusion of the full-load temperature test, with full-load current and normal full-load voltage at the terminals when running at full-load engine speed, the voltage across the shunt field regulator with an ambient of 60° F. (15·6° C.) is not to be less than 14 per cent of the terminal voltage of the machine. The regulator is to be capable of reducing the no-load voltage to 10 per cent below the rated voltage with the generator cold and with the same ambient air temperature.

7. **Alternating-Current Generators.**—(*a*) Where alternating-current generators are to be operated in parallel, the permanent variation in speed of the prime mover between full-load and no-load is to be deemed for the purposes of load sharing to be 4 per cent.

(*b*) Where alternating-current generators are installed means are to be provided for automatically maintaining the steady voltage within plus or minus 2½ per cent of the normal voltage.

(*c*) In alternating-current systems, with one generator set as standby, the remaining sets are to have sufficient reserve capacity to permit the starting of the largest motor in the ship without causing any motor in service to stall owing to excessive voltage drop on the system.

8. **Generator Rating Plate.**—Every generator is to be fitted with a rating plate clearly and indelibly marked with the following information :—

(*a*) Maker's name and machine number.

(*b*) Nature of supply—D.C. or A.C., voltage, frequency, number of phases, etc.

(*c*) Amps. power-factor, K.V.A.

(*d*) Speed.

(*e*) Winding type, i.e., compound, shunt, separately excited.

(*f*) Excitation voltage if separately excited.

9. **Testing.**—Every generator is to be tested at the maker's works, and a certificate giving the results is to be submitted for approval.

The tests are to include :—

(*a*) A temperature test at full load.

(*b*) Regulation (compounding).

(*c*) Voltage range with shunt regulator.

(*d*) Insulation resistance.

(*e*) High potential test.

Machines of 100 kw. and over intended for supplying essential services are to be inspected by the Surveyors during manufacture and testing.

10. **Construction of Generators.**—(*a*) All working parts of generators are to be readily accessible, and all accessible live parts the voltage of which exceeds 250 volts direct-current to earth or 150 volts alternating-current to earth are to be suitably guarded or enclosed.

(*b*) Only Class A or Class B insulating materials in accordance with Appendix No. 2 are to be used in the construction of generators. All generator windings are to be insulated from their frames and/or cores with mica or micanite, and the insulation between bar-wound armature conductors between upper and lower layers or equivalent portions, between which there is periodic full rated voltage, are to be of micanite or other non-hygroscopic non-inflammable material. All generator windings are to be treated to resist moisture, sea air, and oil vapour.

(*c*) Where welding is to be applied to shafts for securing armature arms or spiders, plans showing the construction are to be submitted for consideration.

(*d*) Brush position. The final running position of the brushgear is to be clearly and permanently marked.

11. **Commutator Brushes.**—(*a*) Generator brushes for use on commutators or sliprings are to be of carbon, graphite, or metal-graphite, and are to be provided with flexible copper connections.

(*b*) Commutator brushes are to be staggered longitudinally in such a manner that in multipolar generators every part of the commutator working surface is swept by the brushes, to prevent the formation of ridges. The staggering is to be so arranged that in multipolar generators a positive brush is always in line with a negative brush on an adjacent brush arm.

Generator brushgear is to be mounted on the frame or bedplate of pedestal-bearing machines of 150 kw. per 1,000 revolutions per minute and above.

12. **Terminals.**— Suitable terminals, clearly marked, are to be provided in an accessible position, convenient for wiring, and where cable connections are used they are to be provided with cable sweating sockets. The terminals are to be eflectually secured and are to be so spaced and/or shielded that they cannot be accidentally earthed, short-circuited, or touched.

13.—**Mechanical Balance.**—All generating plant is to be so constructed, erected, and supported, that when running at any and every working speed all revolving and reciprocating parts are well balanced, and the plant is not to give rise to any appreciable vibration on the test bed and in service.

14. **Lubrication.**—(*a*) Generators and their prime movers are to be efficiently and continuously lubricated automatically at all running speeds and all normal working oil temperatures and, except for the generators of emergency sets (*see* clause 20), with the ship inclined from the normal at any angle up to 15 degrees transversely and 10 degrees longitudinally, and when rolling up to 22½ degrees from the vertical without the spilling of oil. Where ring lubrication is employed, the rings are to be so constrained that they cannot leave the shaft. Oil flingers or other suitable means are to be provided to prevent the lubricant from creeping along the shaft, or otherwise gaining access to the insulation of the machine or any live part thereof. Every oil-lubricated bearing is to be provided with a suitable overflow which, while permitting efficient lubrication when the machine is running, is to prevent the bearing from containing an excess of oil.

(*b*) Every self-lubricated sleeve bearing is to be fitted with an inspection lid and means for visual indication of the oil level.

15. **Plant to be Earthed.**—The bedplates and frames of the generating plant are to be effectually earthed, and insulation is not to be interposed between the prime movers and the generators.

16. **Shaft Currents.**—Means are to be taken to prevent the induction of currents likely to circulate between the shafts and the bearings.

17. **Spare Plant.**—Every sea-going ship in which electric power is used for essential services, is, except where other means are available for maintaining these services, to be provided with two or more generating sets of such combined output that in the event of one set being disabled the remaining generating plant is capable of supplying the essential services.

18. **Position in Ship.**—(*a*) The compartments in which the machines are placed are to be well ventilated, and free from the likelihood of an accumulation of inflammable gases. The machines are to be clear of all inflammable material and easily accessible, and they are to be so arranged that under any condition of excitation the compasses are not appreciably affected.

(*b*) Generators are to be placed in positions in which they are not exposed to risk of mechanical injury or to damage from water, steam, or oil. Every open-type generator is to be fitted with a canopy to protect the windings and commutator or sliprings from drip. Suitable handrails are to be provided where necessary to obviate the risk of injury to persons.

(*c*) Generators other than those of emergency sets are preferably to be placed with their axes of rotation in a fore-and-aft direction.

(*d*) No unprotected woodwork or unprotected, readily combustible material is to be within a distance of 12 inches measured horizontally from, or within 4 feet measured vertically above, any generator, unless the latter is of the enclosed type.

19. **Ventilation.**—Ample provision is to be made for supplying clean cool air to, and removing hot air from, the generators, and for preventing the admission of moist or oil-laden atmosphere. Where the generators are not ventilated by a closed system using water coolers, they are to be ventilated with cool air.

20. **Emergency Sets.**—Emergency sets are, if practicable, to be placed with their axes of rotation in a fore-and-aft direction. The lubrication of emergency sets shall be efficient, without the spilling of oil, at all running speeds and all normal working oil temperatures, and with the ship inclined from the normal at any angle up to 22½ degrees transversely and 10 degrees longitudinally.

21. **Clearance from Oil Vents.** — Open-type generators are to be so located that there is adequate clearance from oil vents of gear cases, crank cases, &c., in order to avoid the possibility of the fumes from such vents being drawn into the generators.

Section 3.

SWITCHBOARDS AND SWITCHGEAR

(other than Machine Control Gear, dealt with in Section 13).

1. **Position of Switchboards.**—(*a*) Switchboards are to be placed in accessible well-ventilated positions, free from inflammable gases and acid fumes, and in which they are not exposed to risk of mechanical injury or to damage from water, steam, or oil.

Sufficient ventilation and circulation of air is to be provided to dissipate the heat losses and to prevent condensation.

(*b*) No unprotected woodwork or unprotected, readily combustible material is to be within a distance of 12 inches measured horizontally from, or within 4 feet measured vertically above, any live metal.

(*c*) Cupboards or compartments containing switchboards must be composed of fire-resisting material or approved lining.

2. **Materials.**—(*a*) Switchboards are to be constructed wholly of durable, self-extinguishing, non-absorbent materials of adequate strength except as allowed by clause (*c*) below.

(*b*) Where synthetic insulating material is used, it is to be of permanently high dielectric strength and insulation resistance and non-hygroscopic, and full particulars of appropriate type tests are to be submitted for consideration (*see* Appendix 2, paragraph 2). Only approved materials are to be used. Where used for panels, such materials are to be coated with insulating varnish or enamel over their entire surface, including such parts as have been exposed by drilling or other machining operations.

(*c*) Where semi-insulating materials such as marble or slate are used, all conducting parts on each insulated pole are to be insulated from the slate or marble slabs with bushes and washers of mica or other non-absorbent insulating material.

3. **General Construction.**—(*a*) The various live parts are to be so arranged, by suitable spacing or shielding with non-ignitable insulating material, that an arc cannot be maintained between any such parts or between such parts and earth.

(*b*) All parts, including connections, are to be readily accessible, and live parts mounted on the back of panels and distribution fuse-boards are to be so screened as to prevent them from being inadvertently touched.

Where a voltage exceeding 250 volts direct-current or 150 volts alternating-current to earth is used, the following requirements (i) to (iii) are to be complied with :—

(i) The sides and rear of switchboards and control panels are to be suitably guarded.

(ii) Access doors are to have prominent and permanent nameplates indicating the maximum voltage.

(iii) Exposed live parts operating at such voltages are not to be installed on the face of any switchboard or control panel.

(*c*) Every fuse (other than one protecting an instrument or a pilot lamp) fixed on a switchboard is to be fitted on the front thereof, subject to the exception that it may, if desired, be mounted on a framework behind the switchboard, provided that the fuse is well clear of busbars, connections, circuit-breakers, and live parts, and an unobstructed gangway of not less than 2 feet is left behind the switchboard.

(*d*) All nuts and screws which are used in connetcion with current-carrying parts and working parts are to be effectually locked so that they cannot become loose.

(*e*) The connecting wires to every voltmeter, wattmeter voltage coil, and pilot lamp (if any), and to every earth lamp, are to be protected individually by a fuse on each insulated pole, the fuse being placed as near as practicable to the source of supply except that where such instruments are supplied from a potential transformer with fuses on the primary and secondary sides, a single fuse on each live pole of the secondary side of the transformer may be substituted for the individual fuses for each instrument.

(*f*) Switches and contactors are, whenever practicable, to be so connected that their blades or moving parts are not alive in the "off" or de-energized position.

(*g*) Every equalizer switch and its busbar is to have a current-carrying capacity of not less than half the full-load current of the generator.

(*h*) Switches and fuses fitted on the same pole are, wherever practicable, to be so arranged that the fuses are not alive when the corresponding switches are in the "off" position.

(*i*) Where single-pole switches or fuse-switches are required under these Rules, they are to be fitted on the same pole throughout the installation.

(*j*) Where access is provided behind a switchboard, the unobstructed gangway is to be not less than 2 feet in width, except that this may be reduced to 18 inches in way of stiffeners and frames, and an insulated handrail is to be installed behind the panel.

(*k*) Every open-type switchboard is to be provided with an insulated handrail fitted in front of the panel.

4. **Earthing.**—The following parts of switchboards and switchgear are to be effectively earthed :—

(*a*) The frames, if of metal.

(*b*) The metal cases of instruments used in circuits having a voltage to earth exceeding 250 volts direct-current or 150 volts alternating-current.

(*c*) The secondary windings of all instrument transformers.

5. **Busbars, etc.**—All busbars and busbar connections on switchboards are to be of copper and are to comply with the requirements of Appendix 1.

6. **Fuse-Switches and Circuit-Breakers.**—Where a separate fuse and switch, or separate fuses and a linked switch, are required under these Rules, they may, if desired, be replaced by an overload circuit-breaker (or fuse-switch) or by a linked overload circuit-breaker (or a linked fuse-switch) respectively.

7. **Labels.**—All measuring instruments and all apparatus controlling circuits are to be clearly and indelibly labelled for identification. An indelible label is to be permanently secured to, or adjacent to, every fuse and every circuit-breaker, and marked with particulars of the full-load current of the generator or cable which the fuse or circuit-breaker protects. The labels for rewirable fuses are also to be marked with the appropriate size of fuse-element. Where inverse-time-limit and/or reverse current devices are provided in connection with a circuit-breaker, the appropriate settings of these devices are also to be stated on the label. Nameplates are to be of non-ignitable material, and, if of metal, they are to be so disposed as not to involve risk of short circuits or earth faults.

8. **Inclination, Vibration and Shock.**—All apparatus is to be arranged to function satisfactorily with the ship inclined from the normal at any angle up to 15 degrees transversely and 10 degrees longitudinally, and when rolling up to 22½ degrees from the vertical, and under such conditions of vibration and shock as are likely to arise in practice.

Apparatus connected to the emergency system is to be satisfactory with the ship inclined up to 22½ degrees transversely and 15 degrees longitudinally.

9. **Generator Switchgear.**—Every main switchboard and every emergency switchboard is to be fitted as a minimum with the following switchgear for each generator installed :—

(*a*) Where only one direct-current generator is installed, or where more than one generator is installed, the generators not being arranged to run in parallel :—

(i) If a single-wire or a two-wire earthed system : either a single-pole overload circuit-breaker, or a fuse and a single-pole switch, on the insulated pole.

(ii) If a two-wire insulation system : either a double-pole overload circuit-breaker, or a fuse on each pole and a double-pole linked switch.

(*b*) Where more than one direct-current generator is installed, the generators being arranged to run in parallel :—

For each generator : a circuit-breaker with overload and reverse-current trips. If the generator be flat compounded in accordance with Section 2, clause 5, a single-pole equalizer switch is to be so interlocked with each circuit-breaker that it must be closed before the circuit-breaker and cannot be opened until the main circuit is opened. The reverse-current protection is to be connected on the positive pole (i.e., the pole opposite to that on which the equalizer connection is made).

In a single-wire system or a two-wire earthed system the circuit-breaker is to be of the single-pole type, and in a two-wire insulated system it is to be of the double-pole type.

(*c*) In direct-current three-wire systems where more than one generator is installed the generators being arranged to run in parallel :—

(i) For each generator if shunt-wound : a double pole circuit-breaker with overload and reverse-current protection and a single pole "neutral" isolating switch.

(ii) For each generator if compound-wound, the series field winding being connected to one pole : a circuit-breaker in each "outer" conductor with overload and reverse-current protection, and an equalizer switch interlocked in the manner specified in clause (*b*) above. The operation of the overload release is to be arranged to isolate both poles simultaneously. In addition, a single-pole "neutral" isolating switch is to be fitted.

(iii) For each generator if compound-wound, the series field winding being split, i.e., half the winding being connected to each pole : a circuit-breaker with overload and reverse-current protection in each "outer" conductor and two single-pole equalizer circuit-breakers interlocked in the manner specified in clause (*b*) above. The operation of any overload or reverse-current trip is to be arranged to isolate all poles and equalizers In addition, a single-pole "neutral" isolating switch is to be fitted.

(*d*) Where one or more three-phase alternating-current generators are installed :—

For each generator : a triple-pole linked circuit-breaker with overcurrent trips in at least two phases where the system is three-phase three-wire having the neutral not solidly earthed or with overcurrent trips in each phase where the neutral is solidly earthed or where a three-phase four-wire system is used. In a three-phase four-wire system a generator "neutral" isolating switch or link is to be installed.

Where alternating-current generators are intended for parallel operation, reverse-power relays are to be provided if the generators have a rating exceeding 125 kVA.

10. Main Switchgear for Outgoing Circuits.— Every main switchboard and every emergency switchboard is to be provided with the following switchgear as a minimum for each outgoing circuit :—

A. Two-wire Direct-Current Systems.

(i) If a single-wire or a two-wire earthed system : a fuse and a single-pole switch on the insulated pole.

(ii) If a two-wire insulated system : a fuse on each pole and a double-pole linked switch.

(iii) Where two or more generators, not operating in parallel, are installed : multiple-way switches so controlling each outgoing circuit that the total generating capacity is at all times available for distribution.

B. Three-wire Direct-Current Systems.

(i) For each outgoing three-wire circuit where the supply is given to three conductors : either a double-pole linked circuit-breaker controlling the "outer" conductors, or a fuse on each "outer" conductor and a double-pole linked switch controlling the "outer" conductors.

(ii) For each outgoing two-wire insulated circuit from the "middle wire" and one "outer" of a three-wire system : either a double-pole linked circuit-breaker, or a fuse on each pole and a double-pole linked switch.

(iii) For each outgoing single-wire or two-wire earthed circuit from the "middle wire" and an "outer" of a three-wire system : a fuse and a single-pole switch on the insulated pole.

C. Three-phase Alternating-Current Systems.

(i) For each outgoing three-wire circuit : either a triple-pole linked circuit-breaker with overcurrent trips in accordance with the requirements of 9 (*d*), or, where motors are not connected to the circuit, a fuse in each phase and a triple-pole linked switch.

(ii) For each outgoing two-wire insulated circuit to which a supply is given from one of the three conductors and the "neutral": either a double-pole linked circuit-breaker, or a fuse on each pole and a double-pole linked switch.

(iii) For each outgoing single-wire or two-wire earthed circuit to which a supply is given from one of the three conductors and the "neutral": a fuse and a single-pole switch on the insulated pole.

(iv) For each outgoing four-wire circuit used to supply a section board or distribution fuse-board from which three-wire or two-wire circuits are supplied: either a triple-pole linked circuit-breaker with an overload trip in each phase, or a fuse in each phase and a triple-pole linked switch.

11. **Prohibition of Fuses and Non-linked Switches in Certain Conductors.**—A fuse, non-linked switch, or non-linked circuit-breaker, is not to be inserted in:—

(*a*) The "middle wire" of a direct current or single-phase three-wire circuit.

(*b*) The "neutral" of a three-phase four-wire circuit.

(*c*) The earthed conductor of a single-wire or two-wire earthed system.

12. **Isolating Link** (three-wire and three-phase circuits).—The requirements of clauses **10** (*b*) (i), **10** (*c*) (ii) and (iii) and **11**, do not preclude the provision (for testing purposes) of an isolating link having at least as large a current-carrying capacity as the conductor which it is intended to isolate. Such link is to be securely fixed to its terminals by bolts or screws, and is to be used to isolate such conductor only when the other conductors are isolated.

13. **Instruments.**—Every main switchboard and every emergency switchboard is to be provided with the following instruments as a minimum:—

A. Two-wire Direct-Current Systems.

(i) Where one generator is installed: one ammeter and one voltmeter.

(ii) Where more than one generator is installed, the generators not being arranged to run in parallel: for each generator installed, one ammeter and one voltmeter.

(iii) Where more than one generator is installed, the generators being arranged to run in parallel: an ammeter for each generator, and two voltmeters. A plug or a linked double-pole multiple-way switch is to be provided to enable one voltmeter to be connected to any one generator before the machine is connected to the busbars; and the other voltmeter is to be permanently connected to the busbars. For compound machines the ammeter is to be connected on the positive pole (i.e., the pole opposite to that to which the equalizer connection is made).

B. Three-wire Direct-Current Systems.

Instruments as specified for two-wire systems, and, in addition, a voltmeter connected between the "neutral" and each "outer" busbar.

C. Three-phase Alternating-Current Systems.

Where only one alternating-current generator is installed, or where more than one alternating-current generator is installed, the generators not being arranged to run in parallel: for each generator, one voltmeter, and an ammeter in each phase conductor or one ammeter and a selector switch designed to permit the reading of the current in each phase.

Where more than one alternating-current generator is installed, the generators being arranged to run in parallel: a wattmeter, and an ammeter in each phase conductor or an ammeter and a selector switch designed to permit the reading of the current in each phase; for paralleling purposes, two voltmeters and a synchronising device, the latter comprising a synchroscope and lamps arranged for "bright" synchronising. A plug or a linked double-pole multiple-way switch are to be provided to enable one voltmeter to be connected to one phase of any one generator before the machine is connected to the busbars; and the other voltmeter is to be permanently connected to one phase of the busbars. All these voltmeter connections are to be made to the corresponding phase of each generator.

14. **Instrument Scales.**—The upper limit of the scale of every voltmeter is to be not less than 120 per cent of the normal voltage of the circuit; and the upper limit of the scale of every ammeter is to be not less than 150 per cent of the current rating of the

circuit in which the ammeter is connected. Ammeters for use with direct-current generators which may operate in parallel are to be capable of indicating reverse-current up to 15 per cent of the rated full load current of the generator.

15. **Earth Testing.**—(*a*) Every main switchboard and every emergency switchboard is, except where one pole or the neutral is solidly earthed, to be provided with suitable means for indicating the state of the insulation of the system.

(*b*) Where an earth-indicating system using lamps and/or voltmeters is adopted, earth-indicating lamps are to be of the metal-filament type each not exceeding 30 watts. The system employing a single lamp is not to be used.

For the special requirement for ships carrying oil having a flash point below 150° F. (65·5° C.) *see* **Section 15.**

NOTE.—To facilitate comparison of the brilliance of earth-indicating lamps they should be of the same colour and size and should be placed not more than 6 inches apart.

16. **Protection of Essential Services.**—Where the auxiliary machinery is entirely or almost entirely electrically driven, means are to be provided to ensure as far as is practicable a continuous supply of power to essential services.

17. Where required under Ministry of Transport Regulations the circuit-breakers are to be so arranged that, in the event of overload or partial failure of the supply of power, the non-essential services are interrupted first, and the essential services are maintained by the generator or generators which remain in operation.

NOTE.—The operating or tripping circuits of the generators referred to in clause 17 should, where necessary, be arranged with auxiliary contacts or similar device to ensure that the generators are completely isolated when the circuit-breakers are in the "off" position.

For "preference" tripping systems the following settings are preferred :—

Over-current settings (expressed as a percentage of the rated current of the generator or circuit to be protected) for the main generator circuit-breakers—50 per cent and for "preference" tripping relays—10 per cent.

The preferred time delays are :—

Main generator circuit-breaker ...	20 seconds
Third tripping circuit-breaker ...	15 seconds
Second tripping circuit-breaker ...	10 seconds
First tripping circuit-breaker ...	5 seconds

Circuits to electrically-driven machinery essential for the preservation of perishable cargo should be included in the last group to be disconnected.

18. **Over-Current Protective Devices.**— Devices for protection against over-current and short circuit are to be of the type shown in the following schedule :—

Current rating of generator or cable protected by device.	Type of device to be used.
Up to 200 amperes	Fuse or circuit-breaker
201 to 300 amperes	Fuse or circuit-breaker*
Above 300 amperes	Circuit-breaker

* It is recommended that a circuit-breaker be used in preference to a fuse.

19. **Switches and Circuit-Breakers.**—Each switch, switch-fuse and circuit-breaker is to comply with the following requirements :—

(*a*) The maximum total temperature of all current carrying parts, with the exception of coils, is not to exceed 70° C. (158° F.) for devices rated up to 2,000 amperes and 80° C. (176° F.) for devices rated above 2,000 amperes; and the temperature rise is not to exceed the following values :—

Rating.	Maximum Temperature Rise.	
	Open Type.	Totally Enclosed.
Up to 100 amperes	20° C. (36° F.)	30° C. (54° F.)
101 to 2,000 amperes	30° C. (54° F.)	30° C. (54° F.)
Above 2,000 amperes	40° C. (72° F.)	40° C. (72° F.)

(*b*) The maximum total temperature and temperature rise of operating coils is not to exceed the values shown in the following table :—

Insulating Material.*	Total Temperature.		Maximum Temperature Rise.	
	Continuously Rated °C.	Int'rmittently Rated °C.	Continuously Rated °C.	Int'rmittently Rated °C.
Class A	90	100	50	70
Class B and Bare Coils	120	130	100	100
Class D	100	110	70	80
Thermal-tripping devices	200	—	160	—

* For complete definition of these classes of insulating material see appendix 2.

(*c*) All stem connected switches are to have the contacts and hinges dowelled or otherwise locked to prevent their getting out of alignment by rotation on the panel.

(*d*) The minimum number of connection nuts for each stud is to be two, but if a nut is required for clamping the part to the base, a third nut is to be supplied in addition.

(*e*) Every switch is to be capable of breaking a load current 50 per cent in excess of its rated current at rated voltage, 100 times for switches rated up to 60 amperes, and 10 times for larger switches, and be capable of being put into service at the conclusion without injurious overheating.

(*f*) Every circuit-breaker is to be so adjusted that it will open the circuit when a current flows equal to twice (or less than twice) the rating of the smallest cable or bare conductor it is installed to protect, provided that this requirement is not to apply to a motor circuit installed in accordance with Section 5, clause 2 (*b*). Overcurrent settings are to be calibrated in amperes.

NOTE.—It is preferred that the over-current setting of a circuit-breaker (expressed as a percentage of the current rating of the cable which it protects) should be in accordance with the appropriate item in the following Schedule :—

	Over-current settings
Continuously rated circuits	25 per cent
Generator circuits and intermittently rated circuits	50 per cent
Steering-gear circuits and emergency circuits ...	100 per cent

(*g*) Where reverse-current protection is provided the device is to operate at not more than 15 per cent of the rated full-load current of the generator with rated voltage across the potential coil, at any permissible temperature within the working range.

The action of the reverse-current mechanism is not to be rendered inoperative by a reverse current of excessive value provided the applied voltage is not reduced by more than 50 per cent. A fall of 50 per cent in the applied voltage is not to render the device inoperative, but it may alter the amount of reverse current required to open the breaker.

(*h*) Every circuit-breaker rated at more than 15 amperes is to be of the free-handle type, and is to be provided with suitable means of adjustment for determining the current at which it is to open the circuit.

(*i*) Every circuit-breaker is to be so constructed that, irrespective of the method of tripping and the conditions of load, it will when operated break the circuit effectually and without undue arcing.

(*j*) Circuit-breafers are to be so arranged and placed that no inflammable material is endangered by their coming into action, and that the arc cannot reach earthed metal.

(*k*) Where the current to be interrupted by a switch or circuit-breaker is of such magnitude as to cause damage to the contacts, suitable arrangements are to be made for the easy renewal of the damaged parts, without requiring the removal of the apparatus from its place.

(*l*) The handles and operating mechanisms of switches and circuit-breakers are to be mechanically strong, and are to be so designed and arranged that the hand of the operator, when using the device, cannot accidentally touch live metal or be injured through an arc arising from the switch or circuit-breaker or the blowing of an adjacent fuse. If switches are enclosed, their handles are not to operate through unprotected slots.

(*m*) Where switches are not fixed on a switchboard, the live parts are to be enclosed by covers of non-ignitable material. In positions in which they are liable to mechanical injury the covers are to be of rigid metal or are to be protected by a suitable guard. In other positions the covers may be either of rigid metal or non-conducting material. Metal cases are to be well clear of live parts, and where the switches are to operate at voltages exceeding 125 volts and are rated for currents exceeding 6 amperes, any parts of the cases which are adjacent to arcing contacts are to be lined with non-ignitable insulating material.

(*n*) All switches fixed in positions exposed to the weather, to drip, or to an excessively moist atmosphere, are to be contained in weatherproof cases which are to be provided with cable glands or bushings, or be adapted to receive screwed conduit, according to the way in which the cables entering these fittings are run.

(*o*) Each circuit-opening device is to be so constructed and arranged that when placed in the "off" position it cannot accidentally move sufficiently to close the circuit.

20. **Fuses.**—(*a*) Every fuse is to comply with the requirements of Appendix No. 5, and the choice from the categories referred to in the Appendix is to be made with regard to the prospective short-circuit current and the total output of the generators feeding the circuit in which the fuse is connected.

(*b*) Details of the construction and tests for rupturing capacity and temperature rise of fuses are to be submitted for approval and only approved types of fuse are to be installed on switchboards, section boards and distribution fuse-boards.

(*c*) Each fuse is to be permanently and indelibly labelled with the current carrying capacity of the circuit or generator protected by it and with the appropriate approved size of fuse or replaceable element.

(*d*) The current rating of a fuse-element is not to exceed the current rating of the smallest cable in the circuit protected by the fuse-element, provided that this requirement is not to apply to a motor circuit installed in accordance with Section 5, clause 2 (*b*). Table XII gives approximate fusing currents for wires of copper and standard eutectic tin-lead alloy.

(*e*) Every fuse is to be provided with a suitable non-ignitable insulating fuse-carrier of such form as to protect a person handling it from shock and burns.

(*f*) Effectual provision is to be made for retaining in position all fuses subjected to vibration or shock.

(*g*) Where fuses are not fixed on a switchboard they are to be grouped on section boards or distribution fuse-boards, or are to be contained within cases conforming in all respects to the requirements laid down in clause 21.

(*h*) Fuses are not to be placed in socket-outlets or ceiling-roses.

21. Section Boards and Distribution Fuse-boards.—(*a*) Section boards and distribution fuse-boards are to be constructed in accordance with clauses 2 and 3 above, so far as they are applicable, and the fuses fitted on such boards shall conform to clause 20 above.

(*b*) Every section board and distribution fuse-board is to be contained within a protecting case, unless of such size that it is contained in a separate compartment or space in the ship. Cupboards or compartments containing switchboards are to be composed of, or lined with, non-ignitable material.

(*c*) Cases are to be of ample mechanical strength and rigidity and metal cases are to be protected from corrosion. Ample space for wiring is to be provided.

(*d*) Cases are to be of metal, except in passenger and similar accommodation, or in the vicinity of the compasses, where they may be of wood.

(*e*) Where the case is of metal the minimum distance in air between live metal and the case is to be not less than $\frac{1}{2}$-inch, independent of any displaceable insulation, whether bushing or barrier, and not less than $\frac{3}{4}$-inch when measured over the surface of any non-displaceable insulation. The clearance between arcing contacts or fuses and unlined cases is to be such that operation within the rating of the switch, fuse or circuit breaker can be carried out satisfactorily.

(*f*) All wood cases are to be lined with non-ignitable insulating material. The lining is to be clear of live parts by not less than half-inch.

(*g*) Cases not provided with backs forming an integral portion thereof are to have a non-ignitable insulating shield between their contents and the bulkhead or any other structure to which they are fixed.

(*h*) Where glass fronts are provided, the glass is to be of the "wired" type and the fronts are to clear all live parts by not less than $\frac{3}{4}$-inch. Where the boxes are of metal, such fronts may be regarded as insulating shields.

(*i*) Cases fixed in positions exposed to the weather, to drip, or to an excessively moist atmosphere, are to be weatherproof and provided with cable glands or bushings, or be adapted to receive screwed conduit, according to the way in which the cables entering these fittings are run.

22. Joint and Junction Boxes.—Joint and junction boxes are to be constructed wholly of durable, non-inflammable, non-absorbent materials, and all insulation is to be of permanently high electric strength and insulation resistance. The live parts are to be so arranged, by suitable spacing or shielding with non-inflammable, insulating materials, that conductors of opposite polarity or different phase cannot readily be short-circuited. If used in damp situations, such boxes are to be weatherproof.

23. All metal cases are to be earthed.

Section 4.

DISTRIBUTION.

1. Every distribution fuse-board is to be connected either directly or via a transformer to one of the following:—

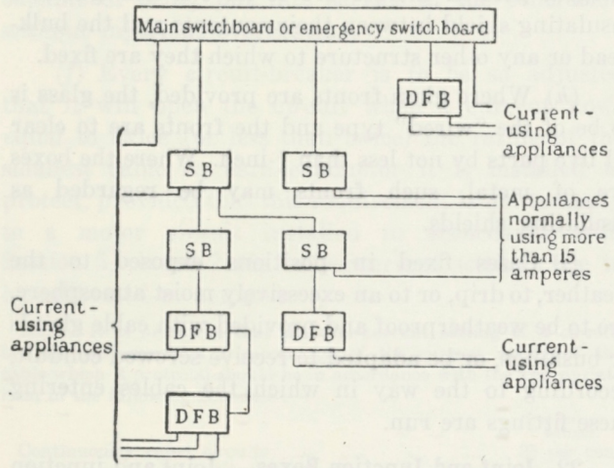
(*a*) The main switchboard or emergency switchboard.

(*b*) A separate way on a section board.

(*c*) One or more other distribution fuse-boards either by looping-in to their busbars or in the form of a ring main. Fuse-links or disconnecting links may, if desired, be inserted in these connecting circuits. The circuit feeding such an arrangement of distribution fuse-boards is to be connected to one

way of the main switchboard, the emergency switchboard or a section board. Where a reduction is made in the cross-sectional area of a conductor, protection is to be provided in compliance with the requirements of **Section 6, clause 10.**

NOTE.—The sequence shown in the following diagram is recognized as standard. The number of intermediate boards intervening between the final sub-circuit and the main switchboard or emergency switchboard will depend upon the size and disposition of the installation.



SB = Section board; DFB = Distribution fuse-board.

2. **Protection Against Excess Current.**—Throughout an installation every circuit is, except as prohibited under **clause 3** (*c*), to be protected on each insulated pole by a fuse or circuit-breaker.

3. **Control of Circuits.**—(*a*) Every outgoing circuit from a section board or a distribution fuse-board is to be controlled by a fuse on each insulated pole, and every two-wire circuit rated at more than 100 amperes is, in addition, to be controlled as a minimum by a switch on one insulated pole.

(*b*) Every three-phase three-wire circuit is to be controlled by a triple-pole linked circuit-breaker with an over-current release in each insulated pole or, alternatively, by a fuse in each insulated pole and for every circuit rated in excess of 60 amperes, by a triple-pole linked switch.

(*c*) A fuse, non-linked switch, or non-linked circuit-breaker, is not to be inserted in that pole of the circuit which is either earthed or derives its polarity from an earthed conductor, but an isolating link securely fixed to its terminals by bolts or screws may be fitted for testing purposes.

NOTE.—Requirements for the control of outgoing circuits from main switchboards and emergency switchboards are contained in **Section 3, clause 10.**

4. **Earth Return.**—Only ships having steel hulls are to be wired on the single-conductor system; hence such system shall not be used on composite ships.

5. **Earthing of Neutral.**—(*a*) Where the distribution is effected on the three-wire direct-current system, or three-wire or four-wire three-phase alternating-current system, whatever the voltage of supply, the neutral may, if desired, be earthed.

(*b*) Where the voltage exceeds 250 volts across the outer conductors of a three-wire direct-current system, the "middle-wire" is to be solidly and permanently earthed at one point only.

6. **Earthing Connections.**—(*a*) Every earthing lead (other than those provided for in **clause** (*b*) below) is to be of stranded or solid phosphor bronze or high-conductivity copper, and is to be protected wherever exposed to the likelihood of mechanical damage, and also, where necessary, against corrosion, particular attention being given in these respects to the point of connection to the hull of the ship. The nominal cross-sectional area of such earthing lead is to be not less than 0·007 square inch for every 50 amperes of working current, provided that its sectional area is in no case less than 0·0045 square inch and is the same as the sectional area of the working conductor for all sizes up to 0·007 square inch. Its sectional area need not exceed 0·1 square inch. The nominal cross-sectional area of every phosphor-bronze earthing lead is to be such as to provide a current-carrying capacity not less than that which would be required for a copper earthing lead.

Where connections are made to conduit or pipes they are not to be made by means of the screw or screws which are used for tightening the clamp to the pipe or by means of saddle fixing screws. Provision is to be made for attaching the earthing lead to the clamp by means of an independent screw or by sweating.

NOTE.—Where earthing leads are exposed to the weather it is preferred that phosphor bronze be used in preference to copper.

(*b*) Every conductor used to carry the working current of a circuit to the ship's structure on the single-conductor system of distribution is to have a cross-sectional area not less than that of the corresponding conductor of the insulated portion of the circuit.

(*c*) Every connection to the ship's structure is to be in an accessible position, and is to be secured by a brass screw of not less than $\frac{3}{8}$-inch diameter used for this purpose only. Where a cable socket is not used (*see* Section 9, clause 1) the wires are to be formed into a hook and placed under a tinned brass washer. In all cases care is to be taken to ensure bright metallic surfaces at the contact areas immediately before screwing up.

7. **Two-wire Circuits above 250 Volts.**—Where the voltage exceeds 250 volts, the following conditions are to be observed :—

(*a*) Motors only are to be supplied at such higher voltages and no portable motor of any size nor direct-current motor having a rating less than one brake horse-power nor alternating-current motor having a rating less than one quarter horse-power shall be so supplied.

(*b*) All exposed metalwork, other than that designed to be live, is to be effectually connected to earth.

(*c*) All apparatus is to be so constructed, enclosed, and protected, that there shall be no danger of shock in the ordinary handling thereof.

(*d*) If the primary means of isolation is remote from the apparatus supplied, an additional means of isolation is to be installed adjacent to the apparatus, or, alternatively, provision is to be made for locking the primary means of isolation in the "off" position.

NOTE.—Requirements for generators, motors, and cables, for voltages exceeding 250 volts are contained in Sections 2, 9 and 12.

8. **Three-Wire Circuits above 250 Volts.**—Where three-wire distribution is employed and the voltage across the outer conductors exceeds 250 volts, the voltage between any two points in one space or compartment where portable fittings, appliances, or accessories are likely to be used is not to exceed 250 volts, unless the fittings, appliances, or accessories, between which there may be a higher voltage, are so situated that they cannot be brought within 6 feet of each other.

9. **Alternative Lighting in Engine Rooms, etc.**—In engine rooms and boiler rooms, and in the corridors and stairways leading to the boatdecks of passenger ships, alternate groups of lamps are to be supplied from circuits so arranged that the melting of any one fuse-element (other than a fuse-element on the main switchboard) will not leave these spaces in darkness.

10. **Emergency Supply.**—Where the Ministry of Transport require an emergency supply to be provided, it is to be adequate in amount, and so disposed as to meet all requirements concerning safety imposed by the Ministry of Transport. Emergency circuits are to be connected direct to a change-over switch or switches, which are to be fitted on the emergency switchboard only, to enable such circuits to be quickly transferred from the ordinary source of supply to the source of emergency supply. Where an emergency battery is installed, an indicator is to be provided and is to be arranged to show whether the battery is in service. The indicator should preferably be mounted on the main switchboard.

11. **Shore Connections.**—(*a*) Where provision is required for a supply of electrical energy from a source on shore or other external source, a suitable connection box or boxes is to be fitted in a position convenient for the reception of portable cables from the external source, and containing terminals of ample size and of such form as to enable the conductors to be effectually clamped therein. The terminals are to be connected to the main switchboard by suitable cables permanently fixed. Where the cables are of 300 amperes capacity or less they are to have at the incoming point on each pole fuses and a linked switch of appropriate size. The cables are to be connected to the main switchboard through a switch on each pole. Where it is intended to supply current from the ship's generator to outside sources, a circuit breaker or a switch and fuse is to be fitted on each pole at the switchboard.

Where a busbar voltmeter is not provided, a pilot lamp is to be installed to indicate when the shore supply is connected.

(*b*) Where the arrangements referred to in (*a*) above are made in connection with a three-phase alternating-current supply, a phase-sequence indicator is to be mounted adjacent to the terminals designed for connection to the external source, the indicator being so connected that the phase-sequence of the incoming supply may be checked, and connections corrected if necessary, before any part of the ship's three-phase installation is energised.

12. **Interference with Magnetic Compasses.**—(*a*) Generators, motors, secondary batteries, control gear, resistors, electric cables, and other apparatus producing an external magnetic field when in use,

are to be fitted at such distances from the compass bowl (having regard to the strength of field set up and the facilities for its conduction by magnetic materials) as will reduce the magnetic field produced by such apparatus to a negligible value thereat.

NOTE.—It is recommended that the devices and apparatus, referred to in clause 12 above, should never be less than 10 feet distant from any magnetic compass.

(*b*) A single-conductor direct-current circuit is not, in any instance, to be fitted within 30 feet of standard and steering compasses. In order that the lead and return currents in such circuit shall neutralize one another in two-conductor systems, cables in the vicinity of the compass are preferably to be twin; and single-core cables are to be fixed as close to one another as possible, and are to be equidistant from the compass throughout their length. Cables within the compass binnacle are to be as short and direct as possible; and where such cables are single-core, they are to be twisted together and are not to be coiled into spiral loops.

(*c*) The current input of incandescent electric lamps employed for illumination of the compass card is not to exceed 0·6 ampere. Such lamps are to be so placed that no live part is less than 7 inches from any part of the magnetic system of the compass.

(*d*) Careful tests are to be made during the adjustment of the compasses. The effect of switching on and switching off circuits, motors, and other electro-magnetic apparatus, near the compasses is to be noted, and careful records kept of any errors observed, whether corrected or not.

13. **Navigation Lights.** — (*a*) Each navigation light is to be separately wired from a special distribution fuse-board which is not to supply any other group. This distribution fuse-board is to be placed in a position accessible to the officer of the watch.

(*b*) Each navigation light on a single-conductor system or a two-conductor earthed system is to be controlled by a fuse and a single-pole switch on the insulated pole, and every such light on a two-conductor insulated system is to be controlled by a fuse on each pole and a double-pole linked switch. These switches and fuses are to be fitted on the special distribution fuse-board referred to in clause (*a*) above.

(*c*) Each navigation light is to be provided with an automatic indicator to give an aural and/or visual signal in the event of extinction of the light. Where a visual signal is not employed, the source of supply to the aural device is to be a primary or secondary battery. Where a visual signal is employed and failure of the indicator lamp would result in interruption of the supply to the navigation lights, means are to be provided for bridging the indicator contacts until the faulty lamp is replaced.

NOTE.—Clause 13 (*c*) does not apply to tugs, trawlers, or fishing and similar small ships.

The indicator referred to in clause 13 (*c*) may, if desired, be combined with the special distribution fuse-board specified in clause 13 (*a*).

The efficiencies of navigation lamps are based on a voltage drop in series indicating devices up to 3 per cent of the rated voltage of the circuit.

(*d*) In the event of failure of the circuit supplying the navigation lights, it is to be possible on the bridge to change them over to an alternative circuit.

(*e*) The fixed wiring to each navigation light is to terminate at a watertight plug and socket or preferably at a watertight connection box adjacent to the lantern, and the lamp is to be provided with a short length of flexible cable, securely anchored to the lantern.

(*f*) On single-wire systems every navigation light is to be wired from the distribution fuse-board with two insulated conductors, the earth connection being made at an earth point in the distribution fuse-board.

(*g*) All switches and fuses between the final distribution fuse-board and the main switchboard are to be clearly marked to indicate that they control the supply to navigation lights.

14. **Control of Electric Lift Circuit.**—(*a*) Circuits which supply current to the motor operating an electric lift or hoist are not to be included in any twin or multicore trailing cable used in connection with the control and safety devices of the lift or hoist; and they are not to be connected to a distribution fuse-board controlling final sub-circuits for lighting unless the maximum current (including the starting or accelerating current) of the motor is less than 20 per cent of the total rating of the fuse-ways on the distribution fuse-board, and unless the fuse-way of the motor circuit is clearly labelled.

(*b*) A twin or multicore trailing cable which is used in connection with an electric lift or hoist, and which incorporates any conductor of any circuit operated at the supply voltage, is not to include any conductor of an electric bell or similar signalling

circuit which is operated at reduced voltage from the supply system, or which is energized from another source.

15. **Steering Gear.**—Where the steering gear is operated by two independent machines and both are driven by electric or electro-hydraulic power they are to be supplied by two independent circuits and a change-over switch is to be fitted in the steering compartment or other approved position to enable the supplies to be interchanged. Each circuit is to be connected direct to the main switchboard.

The cables for each circuit are to be led by independent routes so that, as far as practicable, damage to one does not involve the other.

16. **Control of Oil Fuel Pumps.**—Where the motive power of oil fuel transfer and unit pressure pumps is an electric motor provision is to be made for stopping the motor from a position which will always be accessible in the event of fire taking place in the compartment in which they are situated as well as in the compartment itself.

17. **Transformers for Power and Lighting.**—(*a*) Transformers in accommodation spaces are to be arranged for "air natural" cooling. In machinery spaces they may be arranged for air cooling or be oil immersed. Wherever situated the transformers are to be of drip-proof construction.

(*b*) Transformers are to comply with the requirements of Appendix No. 10.

(*c*) The compartments in which transformers are placed are to be well ventilated and free from the likelihood of an accumulation of inflammable gases, The transformers are to be clear of all inflammable material, easily accessible, and not exposed to risk of mechanical injury or to damage from water, steam or oil. Cupboards or compartments containing transformers are to be composed of, or lined with, non-ignitable material.

(*d*) Oil-cooled transformers are to be preferably of the conservator type, and be so designed that, under all conditions with the ship inclined from the normal at any angle up to 15 degrees transversely and 10 degrees longitudinally, and with rolling up to 22½ degrees from the vertical, they are to operate without the risk of spilling oil. Means are to be provided to permit breathing through a suitable dehydrator.

(*e*) All windings of air-cooled transformers are to be treated to resist moisture, sea-air and oil-vapour.

(*f*) The voltage regulation at full-load and unity power factor of transformers used to supply lighting circuits is not to exceed 2½ per cent. for transformers rated at 5 kVA per phase and over or 5 per cent. for transformers rated at less than 5 kVA per phase.

It is preferred that adjusting tappings should not be provided.

Section 5.

THE ARRANGEMENT OF FINAL SUB-CIRCUITS.

1.—(*a*) Every final sub-circuit is to be connected to a separate way on a distribution fuse-board or section board, or to the main switchboard or emergency switchboard.

(*b*) A final sub-circuit having a rated capacity not exceeding 15 amperes may supply any number of points up to ten. A final sub-circuit having a rated capacity exceeding 15 amperes is not to supply more than one point.

(*c*) In cornice lighting, panel lighting, and electric signs, where lampholders are grouped in close proximity to each other and are connected to the circuit without flexible cords, each lampholder is not, for the purposes of clause (*b*) above, to be deemed to be one point. In these circumstances more than 10 lampholders may, if desired, be connected to a final sub-circuit, provided that the maximum working current in such sub-circuit does not exceed 10 amperes.

NOTE.—Where a circuit for a pilot lamp in connection with a current-using appliance is connected through a local fuse or fuses to the final sub-circuit supplying the appliance, such pilot-lamp is not, for the purposes of these Rules, deemed to be a final sub-circuit.

2. **Protection against Excess Current.**—(*a*) Every final sub-circuit is, except as prohibited under Section 4, clause 3 (*c*) to be protected on each insulated pole by a fuse or circuit-breaker with overcurrent release in each insulated pole.

(*b*) Where the starting or accelerating current of a motor considerably exceeds the rated full-load current, overcurrent protection is to be provided for the motor circuit, but such protection is to be so designed as to allow an excess current to pass during the normal accelerating period of the motor concerned.

(*c*) A fuse smaller than one rated for a normal working current of 3 amperes need not be inserted in any final sub-circuit.

3. (*a*) In every installation the lighting circuits are to be supplied by final sub-circuits separate from those for heating and for power requirements. This requirement does not preclude the supply of cabin fans from lighting circuits.

(*b*) All lighting circuits in cargo spaces are to be controlled by a double-pole linked switch located outside such spaces. Provision is to be made for the complete isolation and for the locking in the "off" position of the control of every such circuit.

4. **Control of Final Sub-Circuits.**—Every two-wire circuit rated at more than 60 amperes is to be controlled as a minimum by a switch on one insulated pole.

Section 6.

CONDUCTORS.

1. **Standard Sizes.**—The sizes of conductors shown in **Tables I, II, and IV,** are recognized as standard for ship installations.

2. **Material.**—(*a*) All conductors of cables are to be of annealed copper having an elongation of at least 15 per cent when determined by a test piece not less than 6 inches nor more than 12 inches long and conforming in all other respects to the Standards of the International Electrotechnical Commission Publication No. 28.

(*b*) Where the insulating covering of the conductor of a coble is composed of vulcanized rubber, each wire is to be effectually and uniformly coated with tin free from all impurities, and the tinned conductor of the finished cable is to be capable of withstanding the tinning test set out in Appendix 7.

(*c*) Where the insulating covering of the conductor of a cable is cambric impregnated otherwise than with a bituminous-base compound, an effective separating tape is to be inserted between the cambric and the lead-alloy sheathing, and, where the conductor is not tinned in compliance with clause (*b*) above, also between the cambric and conductor.

(*d*) All busbars, busbar connections, and bare conductors are to comply with the requirements of the appropriate clauses, Appendix 7. Aluminium is not to be used.

3. **Minimum Size of Conductor.**—The smallest conductor for fixed wiring is to have a normal cross-sectional area of not less than 0·0015 square inch.

4. **Maximum Size of Single Wire.**—All conductors of cables having a nominal cross-sectional area exceeding 0·003 square inch (1/·064 in.), except the conductors of mineral-insulated copper-sheathed cables, are to be stranded.

5. **Current Carrying Capacity of Cables.**—Every conductor of a cable (other than a flexible cord or flexible cable, for which see **Section 8**) is to be capable of carrying, without the respective ratings set out in **Tables I** and **II** inclusive being exceeded, the maximum current which will normally flow through it, provided that:—

(*a*) For final sub-circuits a diversity factor is not to be applied.

(*b*) For circuits other than final sub-circuits a diversity factor may be applied, provided that the known or anticipated conditions are suitable for the application of diversity.

NOTE.—It is impossible to specify in these Rules the value of the diversity factor for every type of installation. For the application of diversity to circuits supplying cargo-winches, cranes, windlasses, and capstans, see clause 6 below.

(*c*) For an electric motor, the maximum current is to be deemed to be the full-load rated current of the motor, and, unless the actual current be known, is to be taken to correspond to the values given in **Table XIII** for the types referred to therein. For motor outputs between those shown in the Table, the full-load current is to be taken to be directly proportional to the output and is to be calculated from the next lower output given in the Table.

(*d*) Where the load on a cable is intermittent, the cable is permitted to carry a larger current (subject to voltage drop) than if continuously loaded. **Table III** gives the maximum permissible currents for half-hour and one-hour ratings. In no case is a shorter rating than one half-hour to be taken whatever may be the degree of intermittency.

(*e*) In assessing the current rating of lighting points for the purpose of determining sizes of conductors, every lampholder is to be deemed to require a current equivalent to the maximum load

which is likely to be connected to it, which is, except for the circuits described in **Section 5, clause 1** (*c*), to be assumed to be at least 60 watts, provided that where the lighting fitting is so constructed as to take only a lamp smaller than 60 watts the conductors may be assessed accordingly.

6. Circuits for Cargo-Winches, Windlasses, etc.—(*a*) Cables for the motors of cargo-winches, cranes, windlasses, and capstans, are to be suitably rated for the duty intended, and, unless the duty is such as to require a longer rating, cables for winch motors may, if desired, be half-hour rated (subject to voltage drop) based on the maximum brake-horse-power ratings of the motors. Cables for windlass motors and capstan motors are to be not less than one-hour rated (subject to voltage drop) based on the maximum brake-horse-power ratings of the motors.

(*b*) A diversity factor may, if desired, be applied in calculating the cross-sectional areas of cables supplying groups of cargo-winch motors or crane motors, subject to such factor being based on the proposed duty of the motors and on currents as required by **Table XIV**. Such cables are to be capable of carrying continuously (subject to voltage drop) the current calculated by applying the diversity factor to the total connected load of winch motors and crane motors. Where the cables feeding winch motors and/or crane motors supply, in addition, other equipment, the current upon which the size of the cable is based is to be computed with due regard to the coincidence of the various loads.

7. Equalizer Connections.—Every equalizer connection for use with flat-compounded generators is to have a sectional area of at least 50 per cent of the sectional area of the positive and negative connections to the generator.

NOTE.—To assist proportionate sharing of the load by parallel connected generators, it is recommended that where the lengths of the connections or the rated sizes of the generators are different the section areas of the equalizer connections should be so graded as to ensure that the voltage drop in all of them is equal at full load.

8. Cables for Alternating-Current.—Where single-core cables are used for alternating-current circuits rated in excess of 5 amperes:—

(*a*) The armouring, if any, is to be of non-magnetic material.

(*b*) Magnetic material is not to be used between such cables.

(*c*) Such cables are to be so arranged that the inductive effects of the group are substantially eliminated.

9. Voltage Drop.—The size of conductors is to be so selected that the fall of voltage between the main switchboard busbars and any and every point on the installation, when the conductors are carrying the maximum current under the normal conditions of service, does not exceed 6 per cent of the voltage at the busbars for power, heating and lighting circuits, and 1 volt plus 1 per cent. of the voltage at the busbars for radio apparatus mains when carrying the main and battery-charging loads simultaneously.

NOTE.—Where an independent charging circuit is provided for the radio battery, the last words of clause 9 apply only to the radio-apparatus mains.

10. Relative Sizes of Conductor and Fuse-Link.—In each circuit every cable is to have a current rating not less than that of the fuse-element (or the adjustment of the circuit-breaker) protecting the circuit. Where a reduction in cross-section is made to a conductor, e.g., at an extension or branch thereof, the smaller conductor is to be protected locally by a circuit-breaker or fuse-element of the appropriate rating (*see* **Section 3, clauses 19** (*f*) and **20** (*d*) and **Tables I** to **IV**) except where the adjustment of the circuit-breaker or the rating of the fuse-element protecting the larger conductor does not exceed the rating of the smaller conductor.

Section 7.

THE INSULATION AND PROTECTIVE COVERING OF CABLES.

1. Only the following types of cables, which may be single-core, twin, or multicore, are to be employed:—

(*a*) Vulcanized-rubber-insulated cables and cables having fire-resisting insulation consisting of an inner layer of vulcanized natural rubber and two layers of polychloroprene (e.g., Neoprene) compound ("R.N.N." type):—

(i) Taped, braided and compounded.

(ii) Lead-alloy sheathed (with, if desired, braiding over the lead).

(iii) Lead-alloy-sheathed and armoured (with, if desired, braiding over the armour).

(iv) Polychloroprene - compound - sheathed ("H.R." type). Varnished-calico taped, braided, and compounded with fire-resisting compound; and complying with special test requirements.

(v) Tough-rubber-sheathed in sizes up to and including 7/·036 in (0·007 square inch).

(*b*) Impregnated-paper-insulated cables and varnished-cambric-insulated cables:—

(i) Lead-alloy sheathed (with, if desired, braiding over the lead).

(ii) Lead-alloy-sheathed and armoured (with, if desired, braiding over the armour).

(c) Varnished - cambric - insulated, polychloroprene-compound-sheathed, taped, braided, and fire-resisting compounded cables.

(*d*) Mineral-insulated copper-sheathed cables.

2. Where it is desired to use types of cables insulated otherwise than specified in **clause 1** above, sample lengths are first to be submitted for approval, each sample being accompanied by a report from a recognized testing authority regarding the behaviour, properties, and life, of the insulating materials employed.

3. Twin-core and three-core cables are to be circular, i.e., flat-sided cables are not to be used.

4. **Vulcanized - Rubber - Insulated Cables.**—(*a*) Vulcanized-rubber-insulated cables and cables having fire-resisting insulation ("R.N.N." type) are to be insulated with two or more layers of vulcanized rubber, except where the dielectric is applied by the extrusion process, in which case it may be applied in one layer, which, except in single-core polychloroprene-compound-sheathed cables ("H.R." type) and tough rubber-sheathed cables are to be covered with a helical binding of a high-quality cotton tape proofed on one side with rubber and applied, before vulcanization, with a suitable overlap. The whole is to be vulcanized together and is to form a compact homogeneous body; it is not to be possible to separate the layers of rubber, but the tape is to be removable without tearing the rubber. The thickness of the insulation is to be in accordance with the appropriate **Table V** or **VI**.

(*b*) Braided cables are to have a fibrous braiding, thoroughly impregnated with a preservative compound of such a nature as not to have any deleterious action on the rubber or armouring as the case may be. The finish of the braiding is to be smooth and uniform.

(*c*) The interstices between the cores of twin and multicore rubber-insulated cables are to be filled with textile material or rubber and a rubber-proofed cotton tape is to be applied with a definite overlap over the laid-up and filled cores.

(*d*) Tough-rubber-sheathed cables are to have the rubber-insulated core or cores surrounded by a continuous close-fitting sheath. For twin and multicore cables the internal surface of the sheath is to fit the cores so as to fill the interstices. The sheath is to be capable of offering a high degree of resistance to mechanical damage. The thickness of insulation and of the sheath is to be in accordance with the appropriate **Table VI A** or **VI B**.

5. **Impregnated - Paper - Insulated Cables.**—(*a*) Impregnated-paper-insulated cables are to be insulated with layers of paper impregnated with a chemically neutral insulating compound. The paper is to be manufactured from chemical wood-pulp fibre and is to be uniform in texture, strong, long fibred, free from imperfectly pulped materials, metallic particles or deleterious substances. It is not to contain mechanical wood, straw, esparto, or any other low-grade fibrous materials. The thickness of the insulation is to be in accordance with the appropriate **Table VII** or **VIII.**

(*b*) The insulated cores of multicore impregnated-paper-insulated cables are to be laid up with a suitable lay, the interstices are to be filled with paper or jute, and the cable is to be sheathed with lead alloy, in accordance with **clause 6**.

6. **Polychloroprene - Compound - Sheathed Cables ("H.R." Type).**—The cores are to be insulated in accordance with **clause 4** (*a*) above and the sheath is to consist of a fire, oil and weather-resisting tough rubber-like polychloroprene compound (e.g., Neoprene) which is to form a continuous close-fitting tube. For twin and multicore cables the internal surface of the sheath is to fit the cores so as to fill the interstices.

The sheath is to be taped with a high-quality varnished-calico tape applied with a definite overlap, cotton braided and treated with a suitable flame-resisting compound.

The thickness of insulation and of the sheath is to be in accordance with the appropriate **Table V** or **VI**.

7. **Varnished - Cambric - Insulated Cables.**—(*a*) Varnished-cambric-insulated cables are to be insulated with layers of suitable high-quality varnished-cloth tape or strip, free from wrinkles, blisters, and other imperfections. A viscous, non-drying, and insulating compound is to be used for lubricating and sealing the layers of the varnished cambric. The compound is to be of a mineral base and is not to dry out or deteriorate. The compound is not to drip from the end of a three-foot length of the cable when suspended in a vertical position for 48 hours at a temperature of 170° F. (77° C.). The thickness of the insulation is to be in accordance with the appropriate **Table VII, VII A** or **VIII**.

(*b*) The insulated cores of multicore varnished-cambric-insulated cables are to be laid up with a suitable lay, and the interstices are to be filled with impregnated jute or other suitable filling material.

(*c*) The insulated cores are to be lead-alloy-sheathed or sheathed with polychloroprene compound which is to be oil-resistant and resistant to moisture absorption and to form a continuous close-fitting tube.

Polychloroprene-sheathed cables are to have the insulated core wrapped with a helical binding of cotton tape applied with a definite overlap prior to sheathing and after sheathing are to be cotton braided and treated with a suitable fire-resisting compound.

The thickness of the insulation and of sheathing is to be in accordance with the appropriate **Table VII, VII A** or **VIII**.

8. **Cables for Communication Circuits.**—Cables used for the purpose of internal communications are to be one or other of the types specified in **clause 1** above (*see* **Section 18, clause 4**). The construction of such cables is to be in accordance with the relevant **clause 4, 5, 6,** or **7** above except that the conductor may be 0·001 square inch (1/·036) and the dimensions in accordance with **Table VI C**. The tests are to be the same as for 250 volt cables.

9. **Lead - Alloy Sheathings.** — (*a*) Lead - alloy - sheathed cables are to be provided with a closely fitting sheath of uniform thickness, free from flaws, and having a smooth exterior surface. The metal of the sheath is to be of alloy A, alloy B or alloy E specified below.

Alloy.	Composition (percentage by weight).						
	Tin.		Cadmium.		Antimony.		Lead
	Min.	Max.	Min.	Max.	Min.	Max.	
Alloy A	1·8	2·2	—	—	—	—	The remainder
„ B	0·35	0·45	0·12	0·18	—	—	
„ E	0·35	0·45	—	—	0·15	0·25	

The lead used in these alloys is to have a lead content of not less than 99·90 per cent, and the impurities, including zinc and bismuth, are not to exceed 0·10 per cent. Zinc is not to be present in an amount exceeding 0·002 per cent, nor bismuth in an amount exceeding 0·05 per cent. No scrap is to be used other than that derived from the cable maker's own manufacture.

(*b*) The radial thickness of lead alloy sheathing is not to fall below the value specified in the appropriate Tables (see **Tables V, VI, VII** and **VIII**) by more than 10 per cent plus 10 mils.

10. **Armouring.**—Armoured lead - alloy-sheathed cables are to have over the sheath a layer of hessian tape or other suitable material impregnated with a moisture-resisting preservative compound. On the bedding is to be applied an armouring of annealed and galvanized steel wire. The wires are to have a uniform lay of approximately 10 times the diameter of their pitch circle for wires exceeding 0·08 inch diameter, and of approximately 8 times the pitch circle diameter for wires of 0·08 inch diameter and smaller sizes. The armouring is to be so applied as to present a uniform cylindrical exterior surface. The diameter of armouring wire is to be as specified in **Tables V, VI, VII, VIII** and **IX**, and the thickness of the bedding, measured before the armouring is applied, is to be in accordance with **Table IX**.

11. **"H.R." Type Cable.**—"H.R." type cable is to consist of a rubber insulated core having a sheath of special oil-resisting rubber compound, taped and braided and treated with a flame-resisting compound. Suitable type tests are to be carried out and the results submitted for consideration. Only approved makes are to be used.

12. **Multicore Cables.**—All the stipulations contained in these Rules relating to quality, dimensions, and tests, of single-core cables are, so far as they apply, to govern the construction of twin and multicore cables.

13. **Contactor Coil Circuits.**—The insulation of cables for highly inductive circuits such as contactor operating circuits for winches, windlasses, capstans and steering gear shall, as a minimum, be 660-volt grade.

14. **Mineral-Insulated Copper-Sheathed Cables.**—The thickness of insulation and nominal overall diameters of mineral-insulated copper-sheathed cables are to be in accordance with **Table XVIII.**

The insulation, unless otherwise approved, is to consist of compressed magnesium oxide, which shall form a compact homogeneous body.

15. **Testing and Inspection.**—The prescribed tests and inspections are to be made at the place of manufacture prior to despatch and may be required to be carried out under the supervision of the Surveyor; but, in the event of any of the material proving unsatisfactory in the course of being installed in ships, such material shall be rejected, notwithstanding any previous certificate of satisfactory testing.

16. **Tests of Dielectric of Cables.**—(*a*) A voltage test is to be carried out on all cables at approximately room temperature with alternating current of sine wave form at a frequency between 25 and 100 cycles per second, and the root mean square of the voltage is to be as stated below for the appropriate grades of cable and maintained continuously at the full voltage for 15 minutes. The voltage test is to be made on the insulated core at the manufacturer's works after the core has been immersed in water for not less than 12 hours, and while still immersed, except that metal sheathed cables need not be so immersed. The voltage is to be applied between the conductor and the water or metal sheath, which is to be earthed, and between the conductors of twin and multicore cables.

Voltage Tests on Cables.

Grade.	A.C. Test voltage applied for 15 minutes.
	Volts.
250 volt cables and flexible cords	1,500
660 volt cables and flexible cords	3,000
3,300 volt cables	10,000

Alternatively vulcanized rubber insulated cables and fire-resisting polychloroprene insulated cables having conductors with a maximum cross sectional area of 0·06 square inch may be spark tested in accordance with **Appendix** 8.

(*b*) The insulation resistance between the conductor and the water in which the insulated core is immersed, or between the conductor and the lead sheath, for vulcanized-rubber-insulated cables is not to be less than the values given in **Table X.** For cables having fire-resisting rubber-like insulation the insulation resistance is to be not less than 20 per cent of the values given in **Table X.** The temperature of the water is to be at or near 60° F. (15·6° C.). When the temperature is not exactly 60° F. (15·6° C.) the result obtained is to be corrected by the appropriate constant given below.

Temperature Correction for Insulation Resistance.

Temperature °F. 1	Multiplier Constant 2	Temperature °F. 3	Multiplier Constant 4
50	0·773	60	1·000
51	0·793	61	1·026
52	0·814	62	1·053
53	0·836	63	1·080
54	0·857	64	1·108
55	0·880	65	1·137
56	0·902	66	1·167
57	0·926	67	1·198
58	0·950	68	1·229
59	0·975	69	1·261
		70	1·293

The measurement of insulation resistance is to be made after one minute's electrification with direct current at not less than 500 volts.

(*c*) Fire-resisting cables are to comply with the following test:—

A sample of un-taped core, or alternatively of the finished cable, 24 inches long is to be clamped vertically in the middle of a three-sided metal screen approximately 36 inches high, 18 inches wide and 12 inches deep, with open front and closed top, the test being carried out in a room substantially free from draughts. The source of heat is to be a 20B

Barthel burner with standard flame. With the base of the burner at 45° to the line of the sample and the top of the burner 2 inches from the sample and approximately 3 inches from the lower end the fire-resisting properties are to be such that the following requirements are to be complied with :—

Time of application of the burner ...	60 seconds
Maximum period of burning after removal of the flame	60 seconds
Total length of core of cable decomposed	6 inches

Section 8.

THE INSULATION AND PROTECTIVE COVERING OF FLEXIBLE CORDS AND FLEXIBLE CABLES.

1. **Types of Flexible Cords and Flexible Cables.**—Flexible cords and flexible cables other than those dealt with in clause 3, and Section 15, clause 6 (*e*), are to be provided with one of the following protective coverings :—

(*a*) Natural or self-extinguishing artificial silk braiding.

(*b*) Glacé cotton braiding.

(*c*) Fibrous braiding, thoroughly compounded.

(*d*) Hard cord braiding in addition to the covering specified in (*c*) above.

(*e*) Tough rubber sheathing applied directly to the laid-up insulated cores, with or without braiding.

2. Flexible cords and flexible cables are to, except as provided for in clause 3, comply with such clauses of Section 7 as are applicable.

3. Where the conductor temperature exceeds 150° F. (65·5° C.) but does not exceed 176° F. (80° C.), flexible cords for connection to immersion and other heaters are to be one of the following types :—

(*a*) Flexible cords having the conductor insulated with heat-resisting rubber, asbestos roved, and cotton or asbestos braided overall.

(*b*) Flexible cords having the conductor roved with asbestos, insulated with varnished cambric, asbestos roved, and cotton or asbestos braided overall.

(*c*) Flexible cords having the conductor insulated with varnished cambric, asbestos roved, and cotton or asbestos braided overall.

NOTE.—Types (*b*) and (*c*) above are suitable for use in dry situations only.

4. **Current Rating of Flexible Cords and Cables.**—Flexible cords and flexible cables are to be capable of carrying, without the respective ratings set out in Table IV being exceeded, the maximum current which will normally flow through them.

5. **Earth Continuity Conductor in a Flexible Cord or Flexible Cable.**—(*a*) The earth continuity conductor in a flexible cord or flexible cable is to be insulated.

(*b*) In a flexible cord having conductors of a nominal cross-sectional area of 0·0048 square inch or less, the nominal cross-sectional area of the earth continuity conductor is to be equal to those of the current-carrying conductors.

(c) In flexible cords having conductors of a nominal cross-sectional area greater than 0·0048 square inch, and in flexible cables, the nominal cross-sectional area of the earth continuity conductors is to be at least 0·0048 square inch and, in general, not less than one-half those of the current-carrying conductors.

Section 9.

THE INSTALLING AND FIXING OF CABLES.

1. **Cable Ends and Sockets.**—(*a*) Where substantial mechanical clamps are not used, the ends of every conductor having a nominal cross-sectional area exceeding 0·01 square inch (7/·044 in.) are to be provided with soldering sockets of such a size as to contain all the strands of the conductor.

(*b*) Soldering fluids containing acid or other corrosive substances are not to be used.

2. **Preparation of Cable Ends.**—(*a*) When soldering or securing the ends of conductors to sockets or terminals, the insulation is not to be removed further than is necessary to allow the unreduced conductor to enter and completely fill the socket or terminal.

(*b*) The braid, lead, or other covering over the insulation, including the tape in contact therewith, is to be cut back at least half an inch from the end of the insulation in cables up to half-inch diameter (measured over the insulation), and at least one inch from the end of the insulation in cables of greater diameter.

3. **Sealing of Cable Ends.**—(*a*) The exposed conductor and insulation of impregnated-paper-insulated cables and varnished-cambric-insulated cables is to be protected from moisture by being suitably sealed.

(*b*) All the strands at the exposed ends of the conductors of impregnated-paper-insulated cables and varnished-cambric-insulated cables exceeding 0·0045 square inch sectional area are to be soldered together, where such exposed ends are not provided with cable sockets. The ends of the conductors of vulcanized-rubber-insulated cables in damp situations shall be similarly treated.

(*c*) Where vulcanized-rubber-insulated cables operate under exceptional conditions of heat or moisture, or are subject to other deleterious agents, their exposed ends are to be effectually sealed.

NOTE.—Under all conditions the life of vulcanized-rubber-insulated cables is considerably increased if means are taken to exclude air from exposed rubber insulation and from the conductor where it emerges from the rubber insulation.

4. Selection of Cable Runs.—(*a*) Cables are, as far as is practicable, to be fixed in accessible positions, so chosen that the cables are not exposed to drip or accumulation of water or oil, steam or oily vapour, high temperatures from boilers, steam pipes, exhaust pipes, radiators, resistors, or other hot objects, or to avoidable risk of mechanical damage. Unless adequately protected, cables are not to be laid under machines or floor-plates. Cables in winch contactor houses are, as far as is practicable, to be kept clear of the outer steel plating (if any) and away from the heat of the resistors.

(*b*) Cables, other than those specially designed for high temperatures, are not to be installed in any situation in which temperatures greater than the following are likely to be attained:

Type of Insulation.	Maximum Temperature of Cable Surroundings.
Vulcanized Rubber ...	115° F. (46° C.)
Impregnated Paper ...	150° F. (65·5° C.)
Varnished Cambric ...	150° F. (65·5° C.)

(*c*) A vulcanized-rubber-insulated cable is not to be so bent that the radius of the inside of the bend is less than that given in the following schedule.

Unarmoured.		Armoured.
Less than 1 inch overall diameter.	More than 1 inch overall diameter.	
4 times overall diameter of cable.	6 times overall diameter of cable.	6 times overall diameter of cable.

This requirement does not necessarily apply to bends in small cables where entering fittings, terminal boxes, etc.

(*d*) A cable (whether armoured or not) insulated with impregnated paper or varnished cambric is not to be so bent that the radius of the inside of the bend is less than eight times the overall diameter of the cable.

(*e*) Where practicable cables insulated with different types of dielectric are not to be bunched in a common clip, gland, conduit or duct.

5. Support and Protection.—(*a*) All cables (other than flexible cables connected to portable or movable fittings) are to be securely fixed in position in accordance with the requirements of clauses 6, 7, and 8, below.

(*b*) Where exposed to risk of mechanical damage, cables shall be protected by sheet-iron plating or by heavy-gauge screwed steel conduit. The use of copper conduit is permitted. Copper conduit is not to be used in situations where it will be exposed to mechanical damage unless further protected by sheet-iron plating or other similar shielding.

(*c*) In machinery spaces, galleys, bathrooms, and laundries, or where unavoidably exposed to the weather or to action of sea water, cables shall be either:—

(i) Lead-alloy-sheathed, with or without further protection; or
(ii) run in conduit; or
(iii) polychloroprene-compound sheathed of the "H.R." type; or
(iv) mineral-insulated copper-sheathed; or
(v) varnished-cambric-insulated conforming with Section 7, clause 7 (*c*) above.

(*d*) Cables entering cold-storage chambers are to pass directly through the walls or lagging of the chamber and are to be protected by a continuous tube flanged at each end; alternatively, they may pass through holes in wood in door frames, in which case the holes are to be sealed at both ends.

(*e*) Cables fixed within cold storage chambers are to be either

(i) lead-alloy-sheathed with or without armouring or braiding; or
(ii) polychloroprene-compound-sheathed of the "H.R." type; or
(iii) mineral-insulated copper-sheathed.

They are not to be embedded in the walls or lagging, but are to be in full view throughout their length. The cables are to be carried on galvanized perforated plating so placed as to leave a space behind the back of the plating and the face of the chamber. As an alternative they may be supported on cleats made of porcelain, hardwood, or other non-metallic and non-hygroscopic material. Where the alternative method is adopted, precautions are to be taken to prevent the casual use of the cables as a means of suspension by the use of hooks placed around the cables.

All metal fixings, including fixing screws, used within a cold-storage chamber are to be galvanized.

(*f*) Every metal-sheathed cable, whether armoured or not, is to have its lead-alloy sheath and armouring (if any) effectually earthed at both ends, provided that in final sub-circuits earthing may, if desired, be at the supply end only. Effectual means are to be taken to ensure that all metallic envelopes of cables are made electrically continuous throughout their length. All earthing connections are to be effected by means of clamps or soldered joints, or, alternatively, by glands specially designed for the purpose of forming part of joint boxes or similar fittings in which cables terminate.

(*g*) Metal staples are not to be used for fixing any cable.

(*h*) Flexible cords are not to be used for fixed wiring.

(*i*) Cables of opposite polarity may, if desired, be bunched in conduit if carrying direct current, but cables carrying alternating current are always to be so bunched that the outgoing and return cables are drawn into the same conduit.

(*j*) Cables carrying alternating-current are to be kept separate from cables carrying direct-current, and if on the same tray they are to be separately supported.

(*k*) Cables shall not be led through or be in direct contact with oil fuel tanks.

(*l*) Excessively large groups of cables are to be avoided.

NOTE.—Attention is drawn to the possibility of corrosion of the lead-alloy sheathings of cables as a result of contact, in the presence of moisture, with oak and other woods.

(*m*) Perforated plating supporting cables in machinery spaces is to be galvanized, or be provided with equally efficient protective coatings applied before erection.

6. **Exposed or Cleated Wiring.**—(*a*) Lead-alloy-sheathed cables, whether armoured or not, vulcanized-rubber-sheathed cables of the "H.R." type, varnished-cambric - insulated polychloroprene - compound-sheathed cables and mineral - insulated copper - sheathed cables may, except as required by **clause 5** (*b*) above, be used without the further protection of casing, duct, or conduit, provided that they are secured by metal clips having smooth or rounded edges. All clips are to be firmly secured by screws of ample strength and are to be spaced in accordance with **Tables XI** and **XI A**. The clips are to be formed of non-rusting material or shall have a non-rusting finish.

(*b*) Cables of all classes having a nominal cross-sectional area of 0·1 square inch and above may, if desired, be suported on cleats, which are to be spaced in accordance with **Table XI** and constructed of porcelain, hardwood, or other non-metallic, non-hygroscopic insulating material. The insulators are to have smooth or rounded edges that will not indent or damage the cable. In damp situations the supports and fixings of the insulators are to be of non-rusting material.

7. **Cables in Conduit.**—Any type of cable (other than the high-voltage cables specified in **Section 17** for luminous-discharge-tube installations) which complies with **Section 7, clause 1**, may be enclosed in conduits, provided that:—

(*a*) The conduits and conduit fittings comply with the requirements of **clauses 9** and **10**.

(*b*) Ventilating outlets suitably placed are provided, preferably at the highest and lowest points of the circuits, to allow circulation of air and to ensure that water cannot lodge in any part of the conduits.

(*c*) The radius of any circuit is such as to permit of compliance with the requirements of **Section 9, clause 4** (*c*) and (*d*), for the bending of cables. In any event the inner radius of the bend is not to be less than $2\frac{1}{2}$ times the outside diameter of the conduit; and elbows or tees, other than those of the inspection type, are not to be used except at the end of conduits immediately behind accessories or lighting fittings.

(*d*) The ends of, and the outlets from, all conduits are bushed or so finished as to prevent abrasion of the coverings of cables emerging therefrom.

(*e*) The saddles and fixings used for securing the conduits are of non-rusting material or have a non-rusting finish.

(*f*) The conduits are earthed and are mechanically and electrically continuous across all joints.

(*g*) Communication cables are not fitted in the same conduit as cables supplying lighting and power, unless the latter cables and/or the communication cables are

(i) lead-alloy-sheathed; or

(ii) polychloroprene-compound-sheathed of the "H.R." type; or

(iii) varnished-cambric-insulated polychloroprene-compound-sheathed.

(*h*) The number of cables in one conduit is such that they can be easily drawn in, and, in any event, is such that the sum of the overall cross-sectional areas of the cables does not exceed for the respective types the following percentages of the internal cross-sectional area of the conduit:—

Braided cables	50 per cent.
Plain lead-alloy-sheathed cables	40 per cent.
Lead-alloy-sheathed cables armoured, with or without braiding over the armour ...	30 per cent.

In every run of conduit facilities are to be provided as may be necessary to obviate the drawing of cables around more than one bend of 90 degrees or two diversions of 45 degrees in the run of the conduit.

(*i*) Armoured cables and cables having fine wire braiding are not to be drawn into the same conduit as cables not similarly protected.

(*j*) All pipes for cables on uncovered weather decks are to be flanged or welded.

8. **Cables in Wood Casing.**—Any type of cable which complies with Section 7, clause 1, may be enclosed in wood casing, provided that:—

(*a*) The casing is used only in dry situations and is not exposed to drip due to condensation or other cause.

(*b*) The casing and capping are secured by screws, which for the capping are to be of brass and fixed on the outer edges only, and nails are not to be driven into the grooves of the casing for holding the cables or for any other purpose.

(*c*) Where the casing forms part of ornamental woodwork, the cables are readily accessible.

(*d*) Direct-current power, heating, and lighting cables of opposite polarity are not to be bunched in the same groove.

(*e*) Precautions are taken to ensure that, where cables from different grooves cross one another, they are separated by insulating material.

(*f*) Communication cables connected to systems having a voltage not exceeding 55 volts are not fitted in the same groove as cables connected to a system having a higher voltage.

(*g*) Armoured cables and cables having fine wire braiding are not to be fitted in the same groove as cables not similarly protected.

9. **Conduits.**—(*a*) Conduits, if of steel, and conduit fittings for use therewith, are, with the exception of inspection and draw boxes, to be of heavy gauge and welded or solid drawn.

(*b*) Conduits, if of copper, and clips and saddles for use therewith, may be used, subject to the requirements of clause 5 (*b*) above, provided full particulars are submitted and found satisfactory.

10. **Inspection and Draw Boxes.**—Inspection and draw boxes are to be of metal and shall be in rigid electrical and mechanical connection with the conduits. For steel conduits this connection is to be obtained by screwing into the box or into a device clamping both sides of the wall of the box. For copper conduits this connection is to be obtained by brazing or soldering a suitable ferrule to the conduit, the ferrule being secured to the box by screwing or by clamping to the wall of the box.

11. **Joints During Erection.**— (*a*) Connections between large vulcanized-rubber-insulated cables are to be made by means of clamped sleeves or tees in joint boxes constructed in accordance with Section 3, clause 22; and those between small cables and between small cables and flexible cables by means of clamped connections contained within suitable receptacles, which in the case of lamp fittings may, if desired, form part of such fittings. Joints in flexible cords are not permissible.

(*b*) Connections between impregnated-paper-insulated cables or between varnished-cambric-insulated cables may, if desired, be made by the same means as for vulcanized-rubber-insulated cables, provided the insulation at their ends is suitably sealed against moisture; or the conductors may be joined by means of copper sleeves, the whole being sweated together. Joints made in this manner are to be lapped with paper or pure cotton tape, impregnated immediately before use, and are to be enclosed in boxes or preferably in lead sleeves or tees wiped on to the cable sheaths, these receptacles being filled with an insulating compound impervious to moisture. Lead sleeves and tees are to be painted with two coats of tough elastic enamel on completion of the joint.

12. **Watertight Glands and Deck Tubes.**—All cables passing through decks or watertight bulkheads are to be provided with deck tubes or watertight glands.

13. **Cables Passing Through Bulkheads, etc.**—Unarmoured cables passing through beams, non-watertight bulkheads, etc., are to have the holes through which they pass bushed with lead or other soft non-ferrous metal, or suitable insulating material.

14. **Circuits of Voltages Exceeding 250 Volts.**—Where a voltage exceeding 250 volts is employed the wiring is to be completely enclosed in strong metal casing or heavy-gauge screwed conduit, or armouring which is electrically continuous, or, alternatively, the cables and other conductors are to be so constructed, installed, and protected, as to prevent danger so far as is reasonably practicable.

15. **Cables in Lift Shafts.**—In lift shafts and hoist shafts all cables, other than trailing cables, are to be armoured or enclosed in steel or other hard-metal conduits. If conduits are used the control leads and motor leads are to be in separate conduits.

In shafts subject to severe condensation, such as engine room lift shafts, the cables (other than trailing cables) are preferably to be of the lead-alloy-sheathed or the "H.R." type, run on the surface of the shaft in such a position as to be clear of wire ropes, trailing cables, etc. Sheet-iron protection covers are to be fitted over cables where liable to sustain damage.

16. **Cables over Expansion Joints.**—Cables are not to be led across expansion joints in the structure unless this is unavoidable. Where cables must cross an expansion joint they shall be arranged with a loop suitably supported having a diameter not less than 12 times that of the largest cable, to ensure the necessary flexibility.

17. **Mineral-Insulated Copper-Sheathed Cables.**—(*a*) Mineral-insulated copper-sheathed cables may, except as required by clause 5 (*b*) above, be used without further protection of casing, duct or conduit provided they are secured by metal clips having smooth or rounded edges. All clips are to be firmly secured by screws of ample strength and shall, where they are clipped direct to steel or wood grounds, be spaced in accordance with **Table XI A.** Where cables are spaced away from the bulkhead the spacing of the clips is to be in accordance with that specified for armoured cables in **Table XI.**

(*b*) The ends of mineral-insulated copper-sheathed cables are to be so sealed as to prevent the ingress of moisture, and all moisture is to be expelled from the dielectric before the sealing material is applied. The sealing material, and any material used to insulate the conductors where they emerge from the dielectric, is to have adequate insulating and moisture-proofing properties and be such as to retain these properties throughout the range of temperatures to which the cable-end is to be subjected during normal service.

Section 10.

ACCESSORIES AND LIGHTING FITTINGS.

1.—(*a*) Accessories and lighting fittings are to be so designed and constructed that the passages for the insulated conductors are of ample size and are free from rough projections, sharp angles, and abrupt bends. All outlets for cables shall have well-rounded edges or be bushed.

(*b*) Accessories and lighting fittings are to be so designed, and the insulated conductors so installed, that stress cannot be applied by the conductors to any terminal to which the conductors may be connected.

(*c*) Accessories and lighting fittings are to be so designed and fixed that dust and moisture cannot readily accumulate on the insulation or live parts.

(*d*) On weather decks, and wherever exposed to spray, drip or condensed moisture, accessories are to be of the watertight type.

(*e*) Watertight accessories are to be so constructed as to withstand, without the entry of water, immersion under a 3-feet head of water for a period of 15 minutes before fixing. After erection they are to be capable of withstanding, without the entry of water, the application of a stream of water ejected without restriction from an ordinary wash-deck hose under a head of 15 feet of water for a period of a quarter of a minute, the outlet of the hose being 6 feet away from the accessory or lighting fitting.

(*f*) The lanterns of navigation lights are to be of non-ferrous construction and to be watertight.

Hygroscopic insulating material is not to be used in such lanterns.

(*g*) Open-type lighting fittings, whether fixed or portable, are not to be used near readily combustible materials, or in spaces where inflammable or explosive dust or gases are likely to be present or where inflammable goods are stored.

(*h*) In spaces where explosive or inflammable dust or gases are likely to be present, accessories and lighting fittings are to be of the flame-proof type.

(*i*) Open-type lighting fittings are not to be furnished with combustible shades unless such shades are kept free from contact with the lamps by suitable guards or supports. Shades and candle tubes composed wholly or partly of nitrated celluloid are not to be used in any situation near a lamp.

(*j*) Switches and other accessories likely to cause an arc when they are operated are not to be installed in bunkers or other spaces in which inflammable or explosive dust, vapour, or gas, is likely to be present, irrespective of whether such switches or other accessories control lights in such spaces.

(*k*) The exposed non-conducting metal parts are to be earthed in accordance with the requirements of clause 8 below.

NOTE.—Where alternating-current portable appliances are to be used in machinery spaces, it is recommended that arrangements shall be made for these to be supplied from a double-wound transformer so designed and connected that the maximum voltage to earth on the appliance and its associated flexible cord or cable shall not exceed 25 volts, the appliances being suitably designed to operate at the reduced voltage.

2. Lighting Fittings.—(*a*) Weatherproof lighting fittings are to have metal frames, and are to be so designed that the lamp is completely enclosed within a readily removable glass receptacle. The cable entries to the fittings are to be watertight, and the cable ends shall be so sealed as to prevent access of moisture to the conductor.

NOTE.—Exposed metal parts should preferably be made of non-ferrous material.

(*b*) Portable lighting fittings for the illumination of decks, holds, engine rooms, and similar spaces, are to be of the open type with frames of metal or other suitable material, or, alternatively, they are to be of the weatherproof type. Suitable guards are to be provided to protect the lamp or lamps from mechanical damage. Switches are not to be fixed on portable lighting fittings.

(*c*) In a portable lighting fitting a metal lampholder which is not in direct metallic contact with the frame of the fitting is to be separated from all metalwork of the fitting by insulating material, of adequate mechanical strength, which will not soften at 302° F. (150° C.), and is to be so shielded by means of similar insulating material that it cannot inadvertently be touched by a person handling the fitting or replacing a lamp. For this purpose a glass bowl of a portable fitting is not to be regarded as an insulating shield for the lampholder.

(*d*) Every portable lighting fitting is to be provided with a hook or other suitable attachment to enable it to be hung up without damage to the flexible cord.

(*e*) Flexible cords for portable fittings are to conform to the requirements of Section 8. The protective covering, of whatever type employed, is to pass into the fitting or plug and be securely anchored thereto.

(*f*) Lighting fittings are to be so designed as to provide for adequate dissipation of heat from the lamps, and the insulated wires connected to the fittings are to be suitably protected from the effects of high temperature.

The design is to be such that the temperature of those parts of the fitting which can be handled and of the terminals to which insulated cables are to be connected does not exceed 130° F. (54° C.) under normal working conditions.

3. Lampholders.—(*a*) Lampholders are, except as otherwise permitted in clause (*b*) below, to be of the following standard types* :—

For lamps up to and including 100 watts	Standard bayonet (B.22) or Medium Edison screw (E.27)
For lamps above 100 watts and not exceeding 200 watts ...	Medium Edison screw (E.27)
For lamps above 200 watts ...	Goliath Edison screw (E.40)

(*b*) Small and miniature lampholders are not to be used on any system operating at more than 24 volts*.

(*c*) Lampholders are to be constructed wholly of non-ignitable material, and all metal parts are to be of robust proportions. Goliath lampholders are to be provided with effective means for locking the lamp in the holder.

* The designations adopted by the International Electro-Technical Commission for lampholders and lamp-caps are as follows :—

Name of Cap.	Designation.
Screw Caps :—	
Goliath	E.40
Medium	E.27
Small	E.14
Miniature	E.10
Bayonet :—	
Normal	B.22
Small single contact	B.15s
Small double contact	B.15d

4. Switches.—Switches are to be constructed wholly of durable self-extinguishing, non-hygroscopic materials.

5. Ceiling Roses.—Ceiling roses are to be constructed of non-ignitable, non-conducting, non-hygroscopic material.

6. Socket Outlets and Plugs.—(*a*) The live parts of socket-outlets and plugs are to be so proportioned that their average temperature does not exceed by more than 54° F. (30° C.) that of the surrounding air when the normal working current is flowing through them continuously.

(*b*) Socket-outlets and plugs are to be so constructed that they cannot be readily short-circuited whether the plug is in or out, and so that a pin of the plug cannot be made to earth either pole of the socket.

(*c*) The clearances of socket-outlets and plugs not interlocked with switches are to be such that an arc cannot be maintained if the plug be withdrawn from the socket while a current 50 per cent greater than that for which they are rated is flowing under a voltage 50 per cent in excess of the voltage of supply.

(*d*) All socket outlets and plugs having a current rating exceeding 6 amperes are to be provided with a switch.

(*e*) On weatherdecks, in stokeholds and engine rooms, and wherever exposed to drip or condensed moisture, socket-outlets and plugs are to be of the waterproof type.

(*f*) Weatherproof socket-outlets and plugs are to be of specially robust construction and be provided with efficient means to maintain the socket-outlet weatherproof when the plug is removed therefrom. Where a loose cover is employed for this purpose, it is to be anchored to a socket-outlet by means of a chain. When the plug is inserted in its socket-outlet the combined fitting and interlocking switch, if any, is also to be weatherproof.

(*g*) Socket-outlets are not to be fitted in bathrooms, lavatories, and similar places.

7. Tubular Fluorescent Lamps.—Where tubular fluorescent lamps (Type MCF/U) are used, the following requirements are to be observed :—

(*a*) All fittings, chokes, capacitors and other auxiliaries are to be of a type suitable for marine service. For all ocean-going ships and ships operating in tropical waters the fittings, chokes, capacitors, &c., are to be capable of operating under tropical conditions. They are not to be mounted on surfaces which are liable to be subjected to high temperatures.

(*b*) Every capacitor having a rated capacitance of 0·5 micro-farad or over is to be provided with a means for its prompt discharge (e.g., a permanently connected parallel resistance) on disconnection of the supply.

(*c*) Linked switches arranged to disconnect all poles of the supply are to be used for all distribution and control switches feeding such lamp circuits.

(*d*) Section boards and distribution fuse-boards for alternating-current supplies feeding such lamp circuits are to be clearly and permanently marked :—

" DANGER.
..... VOLTS A.C."

(*e*) All cables external to the fittings are to be 660 volt grade, and they are to be lead-alloy-sheathed or otherwise suitably screened to prevent radio-interference.

8. **Earthing of Lighting Fittings.**—(*a*) The exposed metal parts of all lighting fittings other than portable lighting fittings are to be earthed. The earthing may be effected by the securing screws where such fittings are secured direct to the steel structure of the ship or to metal plates in effective metallic contact with such structures. Where fittings having exposed metal parts are secured to wood or other non-metallic materials, the earthing is to be effected by a conductor of adequate cross-sectional area and mechanical strength in permanent and substantial connection with the exposed metal parts and the ship's structure.

(*b*) Every portable lighting fitting with exposed metal parts which might otherwise become alive are to have such parts earthed through an earth-continuity conductor which is to be in effective electrical connection with the exposed metal parts and with the earthing pin of the plug connection.

NOTE.—It is recognised that it is difficult to ensure that earth connections remain effective, and it is therefore recommended that, wherever practicable, fittings which are not to be permanently secured to the steel structure of the ship (e.g., portable fittings and fittings secured to wooden structures) should be of the all-insulated type.

Section 11.

LAMPS.

1. **Arc Lamps other than Searchlight Lamps.**—(*a*) Arc lamps are to have the whole of their live parts insulated from the frame or case.

(*b*) Every arc lamp is to be provided with a globe or lantern arranged to intercept falling particles of carbon, and with wire netting of not greater than 3-inch mesh so arranged as to prevent large pieces of broken glass falling therefrom.

(*c*) Arc lamps are to be so supported that they cannot swing into contact with any metallic object.

(*d*) Every arc lamp circuit is to be controlled by a fuse and switch on each insulated pole. Where more than one pole is insulated the switches are to be linked.

(*e*) Arc lamps are not to be installed or used in positions where inflammable goods are stored, or where inflammable or explosive dust, vapour, or gas, is likely to be present under normal conditions.

2. **Searchlight Lamps.**—(*a*) Searchlight lamps are to have the whole of their live parts insulated from the frame or case.

(*b*) All parts of a searchlight lamp which have to be handled for its operation or adjustment while in use are to be insulated from the circuit with strong, non-ignitable material, of substantial proportions, and be so disposed that there is no risk of shock to the operator.

(*c*) Where a circuit supplies a searchlight of arc lamp type it is to be controlled by a fuse and switch on each insulated pole. Where more than one pole is insulated the switches are to be linked. If a series resistance is used with the searchlight lamp, the controlling switch is to be in the supply leads to the resistance and not between the resistance and the searchlight lamp.

(*d*) The frame of every searchlight connected to a supply system having a voltage of 50 volts or above is to be provided with a suitable terminal to which the earth continuity conductor is to be connected.

3. **Lamps for Navigation Lights.**—All lamps for navigation lights are to be of the Ministry of Transport standard pattern and are to have a rating of not less than 40 watts.

4. **Electric Discharge Lamps.**—(*a*) Where electric discharge lamps or luminous discharge tubes are used, lighting by one or more incandescent filament lamps is to be provided as necessary to ensure safety in the event of the extinction of the discharge lamps.

(*b*) Electric discharge lamps are to be so arranged as to operate satisfactorily with the ship inclined from the normal at any angle up to 15 degrees transversely and 10 degrees longitudinally, and with rolling up to 22½ degrees from the vertical.

Section 12.

ELECTRIC MOTORS.

1. **Rating of Motors.**—(*a*) Motors are to conform to Appendix No. 3.

(*b*) The temperature rises of motors, except pipe-ventilated or water-cooled machines, situated in engine and boiler rooms and on weather decks of all ocean-going ships and ships operating in tropical waters measured in accordance with Appendix No. 3 are not to exceed the limits shown in **Table XVI.**

For motors in such ships located elsewhere than in the engine and boiler rooms and weather decks where the normal temperature of the cooling air will not exceed 104° F. (40° C.) the temperature rises are not to exceed those shown in **Table XVII.**

For pipe-ventilated motors taking cooling air from outside the engine or boiler room where the normal temperature of the cooling air under service conditions will not exceed 104° F. (40° C.) the temperature rises are not to exceed the limits shown in **Table XVII.**

For totally-enclosed water-cooled generators with coolers using sea-water at a maximum temperature of 85° F. (29·5° C.) the temperature rise and maximum temperatures are not to exceed those shown in **Table XVII.**

(*c*) The temperature rises of all motors in ships such as coasters, ferries and harbour craft intended solely for use in Northern and Southern waters outside the tropical belt are not to exceed the limits shown in **Table XVII.**

NOTE.—For alternating-current installations, in order that the highest practicable operating power factor may be obtained, the installation of over-sized motors should be avoided, and motors should be selected to have ratings as close as practicable to the actual load requirements.

2. **Flameproof Motors.**—Are to conform to Appendix No. 6.

3. **Excessive Ambient Temperature.**—Where the temperature of the cooling air exceeds 113° F. (45° C.) in the case of motors where **Table XVI** applies and 104° F. (40° C.) where **Table XVII** applies the permissible temperature rise of the motors is to be reduced by an amount equal to the excess temperature.

4. **Testing.**—(*a*) Each motor intended to be used on essential services is to be tested at the maker's works, and a certificate giving the results is to be submitted for approval.

The tests are to include :—

(i) A temperature test at that rating which produces the greatest temperature rise. In cases where this cannot be predetermined, the machine is to be tested separately under each of its ratings.

(ii) Speed-load characteristics.

(iii) Speed range if variable speed.

(iv) Insulation resistance.

(v) High voltage test.

Machines of 100 BHP and over, intended to be used on essential services, are to be inspected by the Surveyors during manufacture and testing.

(*b*) Where the air circulating fans for refrigerated chambers are electrically driven, plans showing the construction of the motor are to be submitted for consideration and the motors are to be inspected by the Surveyors during manufacture. Type tests on the first motor of each size and type are to be carried out in the presence of the Surveyor in accordance with Appendix 3 and abbreviated tests are to be carried out by the maker and certificates giving the results are to be submitted for approval.

NOTE.—A list of motors considered as typical of essential services is given in Section 24.

5. **Construction of Motors.**—(*a*) **Only Class A or Class B insulating materials, in accordance with Appendix No. 2, are to be used in the construction of motors.**

(*b*) All motor windings are to be treated to resist moisture, sea air, and oil vapour.

(*c*) In motors for essential services, the following additional requirement is to be complied with :—

All motor windings are to be insulated from their frames and/or cores with mica or micanite, and in bar-wound armatures the insulation between conductors between upper and lower layers or equivalent portions, between which there is a periodic full rated voltage, is to be of micanite or other similar non-hygroscopic non-inflammable material.

(*d*) All working parts of motors are to be readily accessible, and all live parts in excess of 250 volts direct current to earth or 150 volts alternating current to earth are to be suitably guarded or enclosed (*see* **Section 4, Clause 7** (*a*).)

6. **Brushes.**—(*a*) **Motor brushes for use on** commutators or slip-rings are to be of carbon, graphite, or metal-graphite, and are to be provided with flexible copper connections.

(*b*) **Commutator brushes are to be staggered longitudinally in such a manner that in multipolar motors every part of the commutator working surface is swept by the brushes, to prevent the formation of ridges. The staggering is to be so arranged that in multipolar direct-current motors a positive brush is always in** line with a negative brush on an adjacent brush arm.

7. **Terminals.**—Suitable terminals, clearly marked, are to be provided in an accessible position, convenient for wiring, and where cable connections are used they are to be provided with cable sweating sockets. The terminals are to be effectually secured and are to be so spaced and/or shielded that they cannot be accidentally earthed, short-circuited, or touched.

8. **Mechanical Balance.**—Every motor is to be so constructed, erected, and supported, that when running at any and every working speed all revolving parts are well balanced, and the motor is not to give rise to any appreciable vibration on the test bed and in service.

9. **Lubrication.**—(*a*) Motors are to be efficiently and continuously lubricated automatically at all running speeds and all normal working oil temperatures when continuously inclined from the normal at any angle up to 15 degrees and when the ship is rolling up to 22½ degrees from the vertical without the spilling of oil, with the exception that the longitudinal angle may be limited to 10 degrees for motors placed with their axes of rotation in a fore-and-aft direction. Where ring lubrication is employed, the rings are to be so constrained that they cannot leave the shaft. Oil flingers or other suitable means are to be provided to prevent the lubricant creeping along the shaft or otherwise gaining access to the insulation of the machine or any live part thereof. Every oil-lubricated bearing is to be provided with a suitable overflow which, while permitting efficient lubrication when the machine is running, is to prevent the bearing from containing an excess of oil.

(*b*) Every self-lubricated sleeve bearing is to be fitted with an inspection lid and means for the visual indication of the oil level.

(*c*) Where forced lubrication is employed, an alternative means of lubrication such as oil rings or an oil reservoir is to be provided if no warning device is fitted, or a period exceeding 30 seconds elapses before the machine comes to rest after the interruption of power.

10. **Earthing.**—The bedplate (if any) and frame of every motor is to be effectually earthed.

11. **Shaft Currents.**—Means are to be taken to prevent the formation of circulating currents which might flow between the shafts and the bearings.

12. **Position in Ship.**—(*a*) Motors are, wherever possible, to be placed in well-ventilated compartments in which inflammable gases cannot accumulate, and in all cases are to be fixed clear of all inflammable material. Where these conditions cannot be complied with, motors fitted in such compartments are to be of the flame-proof type or forced-draught type with supply and exhaust pipes or ducts taken outside the compartment.

(*b*) Motors are, as far as possible, to be placed in positions in which they are not exposed to risk of mechanical injury or to damage from water, steam, or oil. Motors necessarily exposed to such conditions are to be of the following types:—

(i) Totally enclosed, including Totally-enclosed fan-cooled.
(ii) Pipe-ventilated.
(iii) Drip-proof.
(iv) Watertight.
(v) Immersible.

(*c*) Pipe-ventilated motors are to be supplied with air as cool as possible, and the air intakes are to be guarded against the admission of dirt and/or moisture.

(*d*) Motors essential to the safety of the ship in the event of damage (e.g., emergency bilge-pump motors) are to be so installed as to be capable of running for a reasonable period after the compartment in which they are situated has been flooded.

13. **Axes of Rotation.**—Motors, other than those of the vertical-spindle type, are wherever possible, to be placed with their axes of rotation in a fore-and-aft direction. The end play is to be reduced to a minimum, and adequate provision is to be made for taking the end thrust due to the motion of the ship.

14. **Unprotected Woodwork, etc.**—No unprotected woodwork or unprotected, readily combustible material is to be within a distance of 12 inches measured horizontally from, or within 4 feet measured vertically above, any motor, unless the latter is enclosed.

Section 13.

MACHINE CONTROL GEAR.

1. **General Construction.**—(*a*) Field rheostats, speed regulators, motor starters, and motor controllers, are to be constructed wholly of durable, non-ignitable, non-hygroscopic materials, and unless otherwise guarded from approach, and where used for switchboards, are to be enclosed in non-ignitable cases.

(*b*) Machine control gear is to be unaffected by vibration or shock, and is to operate satisfactorily under all conditions with the ship inclined from the normal at any angle up to 15 degrees transversely and 10 degrees longitudinally, and with rolling up to 22½ degrees from the vertical.

(*c*) The contact-making faces of machine control gear are to be sufficiently numerous to prevent destructive arcing, and the contacts and fingers of motor controllers and contactors are to be capable of withstanding at least 5,000 operations under full-load conditions without undue wear. At full-load current and full voltage, the interruption of the arcs is to be effected without the projection of molten metal and without destructive arcing. The wearing parts are to be easy to replace without completely dismantling the apparatus.

(*d*) Handles and their attachments of machine control gear are to be mechanically strong, and are to be so designed and arranged that the hand of the operator, when using the device, cannot touch live metal, or be injured through an arc arising from the device.

(*e*) Operating handles of machine control gear are not to, under working conditions, have a temperature rise of more than 27° F. (15° C.) above the ambient air temperature.

(*f*) The cases of machine control gear are to be effectually earthed.

(*g*) The clearances and creeping distances are to be suitable to the nature of the insulation provided, the provision made for arc quenching and the operating characteristics of the apparatus. The following figures are to be regarded as minimum values applying to non-arcing parts in favourable circumstances in air and in oil, to earth or between poles or phases.

	Up to 250 V.		Above 250 V. and up to 440 V.		Above 440 V. and up to 650 V.	
	Clearance.	Creepage.	Clearance.	Creepage.	Clearance.	Creepage.
	inches.	inches.	inches.	inches.	inches.	inches.
Up to 10 amperes	3/16	3/8	3/16	7/16	3/8	1/2
Over 10, up to 75 amperes	1/4	1/2	5/16	1/2	3/8	1/2
Over 75 amperes	3/8	1/2	3/8	5/8	3/8	5/8

The clearance between arcing contacts and the case is to be such that operation within the rating of the apparatus can be carried out satisfactorily.

(*h*) Where a single master-starter system (i.e., a starter used for controlling a number of motors successively) is used, the apparatus is to provide under-voltage and over-current protection, and, for each motor, means of isolation not less effective than that required for systems employing a separate starter for each motor. Where the starter is of the automatic type, suitable alternative means is to be provided for manual operation. Where the starter is employed for the starting of motors for essential services, the starting portion is to be duplicated and means are to be provided for transfer in the event of failure of one of the starters.

(*i*) Where conduit is used for the external connections to machine control gear, the conduit is to be securely attached to the case and is to be so arranged as to enclose the cable completely at the point of entry into the case. Where lead-alloy-sheathed and/or armoured cable is used, provision is to be made to ensure that the metallic sheathing of the cable is so attached to the case of the apparatus as to ensure adequate electrical continuity.

2. **Temperature Limits.**— (*a*) The temperature limits specified in clauses (*c*) and (*d*) below are not to be exceeded. Where the ambient air temperature exceeds 104° F. (40° C.), the specified temperature rise is to be correspondingly reduced so that the specified total temperature is not exceeded.

(*b*) Continuously rated contacts and conductors are to be capable of sustaining the rated full-load current continuously and a 25 per cent overload for two hours after having reached a steady temperature corresponding to full load, without injury to themselves and without causing damage to any adjacent parts.

(*c*) The temperature limits of release, blow-out, contactor-operating, and relay coils which are left in circuit continuously at rated voltage and/or rated current, are not to exceed the values given in Table XV, temperature measurements being made by thermometer or by thermo-couple on the surface.

(*d*) The total temperature of metallic resistors is not to exceed 464° F. (240° C.) at any point [360° F. (200° C.) temperature rise] as measured by a thermometer placed in contact with the resistance material. The total temperature of the air issuing

from a ventilated resistor is not to exceed 284° F. (140° C.), that is a temperature rise of 180° F. (100° C.), measured at a point 1 inch from the case. Where the temperature of any part of the case of a totally enclosed resistor is likely to exceed 170° F. (76·6° C.), the apparatus is to be so located or guarded as to prevent it from being inadvertently touched.

3. Resistors.—(*a*) Internal connections of resistors are not to have soldered joints unless such joints are primarily secured mechanically. Bare connections of resistors are to be sufficiently rigid, or are to be (i) supported to prevent movement, *or* (ii) continuously insulated with porcelain beads, care being taken to prevent short-circuiting at crossings in the event of breakage or displacement of beads, *or* (iii) insulated with fire-proof non-hygroscopic material suitably supported to prevent contact with earthed metal or wires of opposite polarity.

(*b*) Where resistors are not self-supporting or rigidly fixed, they are to be supported throughout their length by non-ignitable, non-hygroscopic insulating material.

(*c*) Resistance elements, other than those of shunt field regulators, are to be readily replaceable.

4. Range of Operation.—Shunt operated contactors, releases and relays are to be capable of functioning satisfactorily even when the line voltage falls to 80 per cent for direct current and 85 per cent for alternating current at any permissible temperature within the working range.

5. Terminals.—(*a*) Suitable terminals with soldering sockets or mechanical clamps are to be provided for the attachment of external leads, and are to be so situated that such leads are not exposed at any point to a high temperature.

(*b*) Soldered sockets are not to be used on resistors unless a separate terminal board, not subject to high temperature, is provided.

6. Position in Ship.—(*a*) Machine control gear is, wherever practicable, to be placed in well-ventilated positions, free from the likelihood of an accumulation of inflammable vapour or gas. When such conditions cannot be complied with, such apparatus is to be flame-proof.

(*b*) Machine control gear is, wherever practicable, to be placed in positions in which it is not exposed to risk of mechanical injury or to damage from water, steam, or oil. Where necessarily exposed to such conditions it is to be totally enclosed. Glazed windows are to be as small as possible, consistent with their purpose, and are to be suitably protected.

(*c*) Resistors are to be placed in well-ventilated compartments, free from the likelihood of an accumulation of inflammable gases, and in such positions as to be clear of all inflammable material. No unprotected woodwork or unprotected, readily combustible material is to be within a distance of 6 inches measured horizontally from, or within 24 inches measured vertically above, the frames or cases of resistors.

7. Control of Motors.—Every electric motor is to be provided with efficient means for starting and stopping, so placed as to be easily operated by the person controlling the motor; and, except for selected motors the continuous availability of which is essential for the safety of the ship, every electric motor having a rating exceeding one-half brake-horse-power is to be provided with control apparatus complying with the following sub-clauses :—

(*a*) Means to prevent the motor re-starting after the under-voltage release has operated where the unexpected re-starting of the motor might cause injury to the operator.

Note.—It is recognised that certain applications require the automatic starting of a motor at irregular intervals in response to control devices which are governed, for example, by thermostatic, pneumatic, or hydraulic devices. In such applications it is intended that the motor should start automatically on the restoration of supply.

(*b*) A starter or switch for limiting the starting and accelerating current to the extent, if any, necessitated by the capacity of the available generating plant or of the cable network.

(*c*) Efficient means of isolation suitably placed and so connected that all voltage may thereby be cut off from the motor and all apparatus, including any automatic circuit-breaker, used in connection therewith.

(*d*) Where the primary means of isolation is remote from a motor, an additional means of isolation is to be installed adjacent to the motor, or, alternatively, provision is to be made for locking the primary means of isolation in the "off" position.

8. Protection of Motor Circuits.—Every electric motor having a rating exceeding one-half brake-horse-power is to be provided with a means to disconnect the supply automatically in the event of the current becoming excessive owing to mechanical overloading of the motor. In the case of polyphase motors, this

shall consist of a linked circuit-breaker or a linked contactor with protective devices so arranged that an over-current in any one phase will disconnect all insulated poles.

NOTE.—To comply with this requirement it is generally necessary to provide local protection additional to that given by means of fuses or circuit-breakers at the source of supply.

9. **Full-Load Currents of Motors.** — For motor control gear, the maximum current of an electric motor is to be deemed to be the full-load rated current of the motor, and, unless the actual current be known, is to be taken to correspond to the values given in Table XIII for the types referred to therein. For motor outputs between those shown in the Table, the full-load current is to be taken to be directly proportional to the output and is to be calculated from the next lower output given in the Table.

10. **Testing.**—Control gear and resistances are to be tested by the makers with a high voltage applied between the earthed frame and all circuits between live parts forming positions of independent circuits. The test voltage is to be 1,000 volts plus twice the rated voltage, with a minimum of 2,000 volts alternating of any frequency between 25 and 100, maintained for one minute. Instruments forming part of the apparatus are to be included in this test unless the scale-length is 3½ inches or less, in which case they are to be isolated and tested separately at 1,000 volts.

Section 14.

HEATING AND COOKING APPLIANCES.

1. **General Construction.**—(*a*) All electric heating and cooking appliances are to be so constructed and mounted that their supports and those parts which have necessarily to be handled in use cannot become heated to a temperature exceeding 130° F. (54° C.). The heating elements are to be of materials durable at the highest temperature which they attain, and are to be so arranged that they can be readily replaced.

(*b*) The electrical connections between the heating elements are to be effected either by joining parts of the elements themselves or by such construction that the connecting conductor will not deteriorate at the maximum temperature to which it may be subjected. The junction between the elements and switches or external connecting leads is to be effected without solder by suitable connections, which are to be so placed that the temperature of any part of the switches or terminals to which insulated cables may be connected cannot exceed 170° F. (76·6° C.).

(*c*) All connections between heating elements and between heating elements and terminals to which insulated cables may be connected are, unless self-supporting or rigidly fixed in position, to be continuously insulated with suitable non-inflammable material.

(*d*) All live parts, whether heating elements or terminals, are to be carried on non-hygroscopic non-inflammable insulating material.

(*e*) The heating elements of heating appliances are to be suitably guarded. The guards are to be of robust construction and so fitted that they cannot be brought into contact with any current-carrying part.

(*f*) All live parts of cooking appliances are to be so protected that the cooking utensils cannot be brought into contact with them.

2. **Provision for Earthing.**—All heating and cooking appliances, whether portable or fixed, are to be provided with suitable terminals for earthing the metal framework, and such terminals are to be effectively connected to earth.

3. **Control.**—Every heating and cooking appliance, whether portable or fixed, is to be controlled as a whole by a fixed switch, and where a socket-outlet is provided it is to be connected between the switch and the appliance.

4. **Portable Appliances.**—All portable heating and cooking appliances are to be of such shape or so weighted that they cannot easily be overturned, and suitable stowage positions are to be provided for them.

5. **Protection of Inflammable Materials.**—All inflammable materials in the vicinity of heating and cooking appliances are to be protected by suitable fire-resisting materials. Every heating appliance is to be so mounted that there will be at least one inch of air space between the appliance and the deck or bulkhead. Heaters are to be so designed and protected that clothing or other inflammable material cannot be placed over them in such a manner as to cause risk of fire.

6. **Space Heaters.**—(*a*) Heaters are to be such as to heat the surrounding air by convection, except that heaters of the radiation type may, if desired, be used provided they are designed and installed in such a manner as to minimize the risk of fire and full details are submitted in advance for consideration.

(*b*) Heaters are to be durable and all parts are to be of robust construction. The protecting guards are to be strong enough to resist being forced against any current-carrying part. The openings are to be of small size to prevent the heating elements from being short-circuited or injured by accident.

(*c*) Internal connections are to be either bare wires sufficiently rigid to be self-supporting or insulated with non-ignitable non-hygroscopic material suitably supported to prevent contact with earthed metal or wires of opposite polarity. Where porcelain beads are used care is to be taken to prevent short-circuiting at crossings or earthing in the event of breakage or displacement of beads.

(*d*) All screws and nuts are to be effectually locked.

(*e*) All heaters are to be tested at the maker's works and are to withstand 2,000 volts alternating current at any frequency between 25 and 100 cycles per second applied for one minute between all current carrying parts and the metal frame (if any) and/or fixing lugs.

7. **Explosion Risks.**—In situations in which an inflammable vapour or gas is likely to accumulate, heating appliances capable of igniting such vapour or gas are not to be installed.

Section 15.

SPECIAL REQUIREMENTS FOR SHIPS CARRYING OIL HAVING A FLASH POINT LESS THAN 150° F. (65·5° C.).

1. **General.**—Where flame-proof construction is specified in the following **clauses 2** to **16**, the apparatus is to comply with the requirements of flame-proof gear as specified in Appendix No. 6. Further, where **clauses 2** to **16** require flame-proof apparatus to be used, and apparatus is obtainable which is covered by a certificate issued by a competent independent Testing Authority, such apparatus only is to be used.

2. **Nature of Supply.**—(*a*) For direct-current systems the voltage of supply is not to exceed

(i) For power, heating and cooking ... 230 volts.

(ii) For lighting, cabin fans and socket outlets in accommodation spaces ... ... 115 volts.

(*b*) For alternating-current systems the voltage of supply is not to exceed

(i) For power, 250 volts single phase or 440 volts three-phase.

(ii) For heating and cooking circuits if permanently connected to fixed wiring ... ... 250 volts.

(iii) For lighting, cabin fans and socket outlets in accommodation spaces ... ... 115 volts.

(*c*) Lighting circuits, cabin-fan circuits, and heating circuits are not to have any electrical connection with a circuit (or source of supply) of higher voltage than those specified above.

3. **Generating Plant.**—(*a*) Generating plant is to be fitted in the main engine room, or, alternatively, in a well ventilated machinery space separated from the cargo tanks by a cofferdam or equivalent safety space.

(*b*) Two or more generating sets are to be provided of such combined output that, in the event of one set being out of service, the remaining generating plant is to be capable of carrying the normal working load, except that in ships of less than 500 tons gross measurement where the supply is not employed for essential power services one set only need be fitted, provided that the following spares are carried: (i) for direct-current installations a spare generator armature and set of field coils (including commutating-pole coils, where commutating poles are fitted); (ii) for alternating-current installations, a spare armature (rotating or stationary) and two field coils for both the alternating-current generator and the exciter.

4. **Switchboards.**—(*a*) The main switchboard is to be fitted in the same compartment as the generating plant.

(*b*) All switchboards, section boards, distribution fuse-boards, and joint boxes, are to be fitted well clear of boilers, steam or oil pipes, settling tanks, and Diesel-engine exhaust pipes or manifolds.

(*c*) Every outgoing circuit from the main switchboard and section boards is to be provided with a multi-pole (linked) circuit-breaker or, alternatively, a multi-pole (linked) switch arranged to interrupt the circuit on all poles simultaneously, with fuses of the type required in clause 9 (*e*) and (*f*) on each pole.

(*d*) Every earth-indicating device, other than one depending solely on lamps, is to be so designed that the flow of current to earth cannot exceed 30 milliamperes, and the inductance of the path to earth in the indicating circuit is not to exceed 60 millihenries. Where an earth-indicating system using two lamps is adopted, such lamps are to be of the metal-filament type, each not exceeding 15 watts. The system employing a single lamp is not to be used.

NOTE.—To facilitate comparison of the brilliance of earth indicating lamps they should be of the same colour and should be placed not more than 6 inches apart.

5. **Distribution.**—No current-carrying part of the system, except as provided for in clause 4 (*d*), is to be earthed.

6. **Cables.**—(*a*) All cables, other than mineral-insulated copper-sheathed cables, flexible cables and cables in accommodation and machinery spaces (*see* clause (*b*) below), are to have the protective sheathing specified in the following par. (i) or par. (ii), according to the conditions under which they are installed :—

(i) Where run open, with or without additional protection from mechanical damage :—Lead-alloy-sheathed and armoured with or without braiding over the armour.

(ii) Where protected from mechanical damage or run in pipes.—Lead-alloy-sheathed and either armoured or metal braided.

(*b*) Cables (other than flexible cables) in accommodation and machinery spaces are to be lead-alloy-sheathed (with or without braiding, armour or armour and braiding) or mineral-insulated copper-sheathed.

(*c*) The cables referred to in clause 7 (*b*) are to be insulated with varnished cambric, or with rubber of highest quality and specially suitable for withstanding extremes of temperature.

(*d*) Every flexible cable is to be provided with an earth continuity conductor in addition to the current-carrying conductors and, except for flexible cords in cabins and accommodation, the nominal cross-sectional area of every conductor in the cable is to be not less than 0·003 square inch. The earth continuity conductor in the flexible cable is to be effectively connected to the earth pin of the plug at one end and to the metal, if any, of the portable appliance at the other end. Every flexible cable is also to be provided with means for relieving the conductors of mechanical stress, and is to be so installed that such means are effective. Flexible cords in cabins and accommodation are to comply with the requirements of Section 8, paragraph 5.

(*e*) Every flexible cable is to have the cores so laid up and arranged as to provide the maximum degree of flexibility and freedom from internal damage due to twisting and kinking. For flexible cables having a nominal cross-sectional area greater than 0·007 square inch, an external close-fitting sheath of tough rubber reinforced with embedded canvas is to be fitted, and it is to be of sufficient thickness and strength to protect the cores from external damage by heavy compression and abrasion.

7. **Installation of Cables.**—(*a*) Cables are to be so installed that they are not subjected to tension or chafing due to the working of the ship's structure.

(*b*) Cables installed on deck or under fore-and-aft gangways are to be run either in substantial channels of steel bar or plate, or, alternatively, in galvanized steel pipes fitted with bolted flanged joints or screwed unions. The thickness of the steel pipes is to be not less than that stated in the following schedule :—

Nominal Bore of Pipe. in.	Minimum S.W.G.	Thickness of Pipe. in.
$\frac{3}{4}$	10	0·128
1	9	0·144
$1\frac{1}{4}$	8	0·16
$1\frac{1}{2}$	7	0·176
2	7	0·176
$2\frac{1}{2}$ to 6	6	0·192

(*c*) Where channels or plating are employed the ends are not to be rigidly attached to bulkheads at the poop, midships house, and forecastle, and suitable expansion bends or bights are to be provided in the cables at these points.

(*d*) Where pipes are employed the total cross-sectional area of the cables contained within a single pipe is not to be more than 30 per cent of the internal cross-sectional area of the pipe. Substantial stuffing boxes with adjustable packed glands are to be provided at intervals in the run of pipes to allow for expansion and contraction, and the working of the ship. In

particular, stuffing boxes are to be fitted at each bulkhead through which the pipes pass. The run of the pipes is to be as direct as possible to facilitate the drawing in of cables, and all parts of the pipe system are to be effectively drained and ventilated, and earthed in accordance with Section 9, clause 7 (*f*).

(*e*) All cables, and all pipes containing cables, running fore and aft are throughout their length to be kept at such a distance from steam and exhaust pipes as to be substantially free from any heating effect from such pipes. At the bulkheads this distance is to be not less than 18 inches from the flanges of steam pipes of more than 3 inch diameter, and not less than 12 inches from the flanges of steam pipes of 3 inch diameter or less.

(*f*) The total number of cables which run fore and aft is to be reduced to a minimum.

8. **Voltage Drop.**—In computing the sizes of main cables running forward from the engine room, special care is to be taken to avoid excessive voltage drop (*see* Section 6, clause 9), in view of the length of such conductors on this class of ship.

9. **Fittings and Accessories.**—(*a*) The enclosing cases of all section boards and distribution fuse-boards, are to be wholly of metal and, except in accommodation spaces, are to be watertight. Except in accommodation spaces, enclosing cases of lighting fittings and accessories are to be wholly of metal and are to be watertight or flame-proof as required under clause (*g*) below and clause 10. All metal cases are to be effectively earthed.

(*b*) All switches in distribution circuits are to be of the multi-pole linked type.

(*c*) Switches controlling the lighting fittings referred to in clauses 10 (*a*) and 15 (*a*) are to be fitted in safe positions, and are not to be immediately adjacent to the lighting points.

(*d*) Every socket outlet for use with flexible cables is to be of the three-pin type and is to be so interlocked that it is impossible to withdraw the plug when the switch is in the "on" position or to close the switch when the plug is withdrawn.

(*e*) Every fuse is to be of the indicating type, and the fuse-link is to be entirely enclosed in a non-ignitable non-hygroscopic insulating cartridge filled with refractory material. They are to comply with the requirements of Section 3, clause 20.

(*f*) It is to be impossible to fit a cartridge of higher rating in a given fuse without the use of special tools and parts.

(*g*) Switches and socket outlets other than those of the flameproof type are not to be fitted within 10 feet of any oil tank outlet or vapour outlet.

10. **Lamps and Appliances.**—No lighting fitting, electrical appliance, or wiring of any kind, is to be installed in any oil tank, pump room, cofferdam, or any other space immediately adjacent to and below the top of the oil tanks. Every metal lighting fitting is to be effectively earthed and to have as a minimum the following enclosure corresponding to its position or use in the ship :—

(*a*) In between-deck spaces immediately above, or in exposed positions within a distance of 10 feet from, any oil tank outlet or vapour outlet—Flame-proof.

(*b*) Portable lamps fed by flexible cables—Watertight, and provided with strong metal guards.

(*c*) In engine rooms (except floodlights), store rooms, dry cargo holds, and similar safe spaces, also in exposed positions about the decks, other than those defined in clause (*a*) above—Watertight.

Floodlights in engine rooms may be of the open type provided they are drip-proof and the lamp sockets are of the Edison screw type.

(*d*) Navigation and signal lights—Watertight.

11. **Lamps.**—(*a*) Luminous discharge tubes and electric discharge lamps, other than tubular flourescent lamps (Type MCF/U), are not to be used.

(*b*) Searchlights, other than those required to be fitted in compliance with the Suez Canal requirements for navigational purposes, are not to be of the carbon-arc type. The frames and all non-conducting metal parts are to be effectively earthed.

12. **Portable Appliances.**—The metal frame of every portable electric lamp, drill, and other appliance, fed through a flexible cable is to be provided with suitable means for permanent connection to the earth continuity conductor of the flexible cable, and is to be earthed.

13. **Heating and Cooking Appliances.**—Electrical cooking appliances (except where they are installed in the ship's galley aft of the oil tanks) and all elec-

trical heaters are to be of the "black heat" type, and are to be securely fixed in position and permanently connected to fixed wiring and metal frames are to be earthed.

14. Cabin Fans.—Cabin fans are to be permanently connected to fixed wiring and their frames are to be earthed.

15. Cargo Pump Rooms.—(*a*) Cargo pump rooms and similar machinery spaces are to be adequately lighted by lamps enclosed in flame-proof lighting fittings permanently connected to fixed wiring and fitted wholly outside the space, always provided that pump rooms immediately adjacent to an engine room or similar safe space may be lighted through substantial gas-tight permanently fixed glazed ports, fitted in the bulkhead, and, where the lighting fitting is not immediately in contact with the bulkhead, the fitting used in such safe space need not be of flame-proof type.

(*b*) Portable lamps, other than self-contained battery-fed lamps of a type approved by a competent independent Testing Authority for use in explosive petroleum atmospheres, and gas detecting lamps similarly approved, are not to be used in any oil tank, pump room, cofferdam, or any other space immediately adjacent to and below the top of the oil tanks, unless the atmosphere therein has been tested and certified to be free from such explosive mixtures.

(*c*) There are to be secured in two or more conspicuous positions enamelled iron or similar permanent notices of ample size, prohibiting the use of lamps and other electrical appliances fed by flexible cables:—

(i) about the oil tanks, except with the permission of the Master.

(ii) in the oil tanks, cofferdams, or pump rooms, unless they have been certified to be free from explosive mixtures.

(*d*) Portable lamps and other portable electrical appliances are not to be used unless previously inspected to see that all parts are in position and that the earthing and other connections are in good order at the plug and the appliance.

16. Motors, etc.—Motors and their starting or control gear are to be fitted only in the undermentioned positions, and are to have as a minimum the enclosure corresponding to each position:—

(*a*) Machinery and steering gear spaces—Drip-proof type.

(*b*) Open deck, within 10 feet from an oil tank or vapour outlet—Flame-proof type; elsewhere on open deck—Watertight type.

(*c*) Radio and gyro-compass rooms where not liable to an accumulation of inflammable vapour—Protected type.

(*d*) Living accommodation (small cabin fans only)—Protected type.

Section 16.

SECONDARY BATTERIES.

1. General.—Secondary batteries installed permanently in position, except small batteries of portable types, are to comply with the requirements of clauses 2 to 8 below. The term "battery compartment" implies any compartment, recess or locker occupied by secondary batteries.

2. Construction.—The cells of secondary batteries are to be so constructed as to prevent spilling of the electrolyte due to the motion of the ship and prevent the emission of acid or alkaline spray on to surrounding objects. The containers are to be of strong construction and of non-brittle material; they are not to be of celluloid. The plates are to be of such dimensions and so arranged that they are firmly secured against motion within the containers.

3. Arrangement.—Every battery is to be so arranged that each cell or crate of cells is readily accessible from the top and from at least one side; the cells are, if possible, to be arranged in a single tier. The cells or crates are to be carried on insulators which are either to be integral with them or be separate components of glass, vitreous porcelain, ebonite, rubber, or equivalent material; and insulators of similar material are to be employed to prevent any movement of the cells arising from the motion of the ship.

4. Position of Battery Compartment.—The position of the battery compartment is to be such that no magnetic compass is affected by currents in the battery or in any conductors connected thereto.

The battery is to be located in such a position that it is not liable to be subjected to extremes of temperature.

5. **Protection of Battery Compartment.**— Where acid is used as the electrolyte for the battery, the deck below the cells is to be so protected with lead or other acid-resisting material as effectually to prevent any acid from lodging in contact with the structure of the ship. All metalwork within the battery compartment, including exposed metal on the battery and its connections, is to be protected with acid-resisting paint, unless such metalwork, by virtue of its composition or arrangement, or for other reasons, is not subject to the deleterious effects of acid.

6. **Ventilation of Battery Compartment.**—The battery compartment is to be suitably ventilated so that it is impossible for battery gases to accumulate in appreciable quantities during periods of charging, discharging or standing on open circuit.

7. **Naked Lights.**—A permanent notice is to be exhibited prohibiting naked lights and smoking in the vicinity of the battery.

8. **Control.**—(*a*) Suitable means, including an ammeter and a voltmeter are to be provided for controlling the current with which a battery is to be charged and to protect against accidental discharge into the charging circuit.

(*b*) Switches, fuses and other electrical equipment liable to cause an arc are not to be placed within the battery compartment. The battery cables are to be protected by a fuse in each conductor at a position adjacent to the battery compartment.

Section 17.

LUMINOUS DISCHARGE TUBES.

NOTE.—Section 17 applies to luminous discharge tubes having a normal operating voltage in excess of 250 volts.

1. **General.**—(*a*) External electric signs are not to be installed in a position where they are likely to obscure or be mistaken for any navigation light specified in the International Regulations for Preventing Collisions at Sea.

(*b*) The earthing of electric signs is to be carried out in compliance with Section 4, clause 6 (*a*). It is not necessary to earth metal clips or clamps used in positions remote from the terminals to support luminous-discharge-tubes, unless it is found desirable to effect the earthing of such clips or clamps in order to reduce interference with radio reception.

(*c*) Every motor and other mains-operated apparatus employed for switching or flashing of electric signs is to be connected to an independent final sub-circuit.

2. **Luminous-Discharge-Tube Installations.**—Every luminous-discharge-tube installation is, in addition to complying with such requirements of clauses 1 (*a*) to (*c*) above as are applicable, to comply with the following:—

(*a*) The voltage of primary circuits is not to exceed that permitted for ordinary lighting circuits.

(*b*) The secondary or high-voltage circuit is to be permanently earthed at the transformer, and the core of every transformer is to be earthed.

(*c*) Irrespective of the method of obtaining the voltage of the circuit which feeds the luminous-discharge-tubes, all parts of such circuit are to be isolated from the supply.

(*d*) Notices, made of durable material that will be unaffected by the weather and in size each not less than 18 square inches are to be set up and maintained at points of access to the luminous-discharge-tubes, and where otherwise necessary. The notices are to bear the following wording.—

DANGER.

SWITCH TO BE LOCKED IN THE "OFF" POSITION BEFORE TOUCHING.

The word "DANGER" is to be in large red letters and the word "LOCKED" is to be emphasized. The remainder of the lettering is to be either black or white, depending on the colour of the plate.

3. **Luminous-Discharge-Tube Devices.**—In addition to the requirements of clause 2, fixed interior luminous-discharge-tube devices are to have all live metal parts enclosed in a suitable earthed case constructed of metal or lined with metal, such case being sealed and marked with the word "DANGER" on or near the seal.

4. **Submission of Plans.**—Full details of every luminous-discharge-tube installation, showing the position of all devices in connection therewith, the arrangement of circuits and locked switches and details of construction are to be submitted for approval.

Section 18.

INTERNAL COMMUNICATIONS.

1. **Construction of Transforming Plant.**—Motor-generators and static transformers used for the reduction of voltage for communication circuits are, together with their control gear, to comply with the clauses for similar plant employed for lighting and power supply.

2. **Batteries.**—Primary and secondary batteries are to be readily accessible at all times, and means are to be provided to prevent liquid from the cells coming into contact with the wooden floor or the structure of the ship. Secondary batteries are, in addition, to comply with such requirements of Section 16 as are applicable.

3. **Construction of Apparatus.**—(*a*) Where a communication system derives its supply from the lighting and/or power circuits, or where the voltage of supply exceeds 55 volts, all cables, wires, switches, resistors, distribution fuse-boards, accessories, instruments, and other apparatus comprising such system, are to be designed, constructed and fitted throughout in all respects in accordance with such of the requirements for lighting and power circuits as are applicable.

(*b*) Where a communication system derives its supply from motor-generators, primary or secondary batteries, or static transformers, and is entirely electrically isolated from the lighting and power circuits, and the voltage of supply does not exceed 55 volts, the switches, resistors, distribution fuse-boards, accessories, instruments, and other apparatus in connection therewith, are to be of robust design and construction, and so installed as to ensure an ample margin of safety, having regard to the voltage employed.

(*c*) All materials and appliances, whether the conditions of service are as named in clauses 3 (*a*) or (*b*) above, are to conform with the remaining requirements of these Rules as far as applicable.

4. **Cables.**—(*a*) Cables used for the purpose of internal communication are to be of one or other of the types specified in Section 7, clause 1, except that vulcanized-rubber-insulated cables and cables having fire-resisting insulation ("R.N.N." Type) of conductor size 1/·036 m. may be used and are to be fitted in a similar manner to cables installed for the lighting and power supply of the ship, and they are to be kept separate from the latter, unless the lighting and power cables and/or the communication cables are protected by lead-alloy sheathing or vulcanized-rubber sheathing of the "H.R." type.

(*b*) Communication cables run in wood casing are not to be fixed in the same groove as the cables of lighting and power circuits.

5. **Protection of Circuits.**—Communication circuits, other than those supplied from primary batteries, are to be protected on each insulated pole by fuses of a current rating suited to the maximum current rating of the circuit to be protected.

6. **Identification.**—Communication circuits are to be so arranged and terminal boxes so designed, fitted, labelled, or otherwise marked to facilitate identification, as to enable fault-testing to be expeditiously carried out and the necessary repairs to be made with the minimum possible disturbance to other circuits.

7. **Fire Alarm Circuits.**—The circuits and apparatus of electric fire alarms are to comply with the requirements of clause 3 (*a*) above. Gongs are to emit a powerful and distinctive note.

Section 19.

LIGHTNING CONDUCTORS.

1. **General.**—Lightning conductors are to be fitted to each mast of all wooden, composite, and steel ships having wooden masts or topmasts. They need not be fitted to steel ships having steel masts.

2. **Construction.**—(*a*) In wooden and composite ships fitted with wooden masts, the lightning conductors are to be composed of continuous copper tape and/or rope, having a section not less than 0·15 square inch which are to be riveted with copper rivets or fastened with copper clamps to a suitable copper spike not less than 0·5 inch in diameter, projecting at least 6 inches above the top of the mast. Where tape is used the lower end of the tape is to terminate at the point at which the shrouds leave the mast, and is to be securely clamped to a copper rope of not less than 0·5 inch diameter. This copper rope is to be led down the shrouds and is to be securely clamped to a copper plate not less than 2 square feet in area, fixed well below the light-load waterline and attached to the ship's side in such a manner that it is to be immersed under all conditions of heel.

(*b*) In wooden and composite ships fitted with steel masts, each mast is to be connected to a copper plate in accordance with clause (*a*) above, the copper rope being securely attached to and in good electrical contact with the mast at or above the point at which the shrouds leave the mast.

(*c*) In steel ships fitted with wooden masts, the lightning conductors are to be composed of copper tape or rope terminating in a spike, as set forth in clause (*b*) above. At the lower end this copper tape or rope is to be securely clamped to the nearest metal forming part of the hull of the ship.

(*d*) Lightning conductors are to be run as straight as possible, and sharp bends in the conductors are to be avoided. All clamps used are to be of brass or copper preferably of the serrated contact type, and efficiently locked. No connection is to be dependent on a soldered joint.

(*e*) The resistance of the lightning conductor, measured between the mast head and the position on the earth plate or hull to which the lightning conductor is earthed, is not to exceed 0·02 ohms.

3. **Protection when in Dry Dock.**—It is recommended suitable means should be provided to enable ships when in a dry dock or on a slipway to have their lightning conductors connected to an efficient earth on shore. All floating docks should be provided with appropriate means of earthing the lightning conductors of a vessel supported thereon.

Section 20.

SPECIAL REQUIREMENTS TO BE COMPLIED WITH WHERE THE CONSTANT-CURRENT SERIES SYSTEM IS USED FOR PURPOSES OTHER THAN PROPULSION.

1. **Working Voltage.**—The working voltage of any constant-current series system is not to exceed 650 volts.

2. **Generators and Motors.**—(*a*) Generators and motors are not to be of the open type.

(*b*) Every motor is to be so protected that its speed cannot exceed a predetermined safe limit.

3. **Switchgear.**—(*a*) An automatic device is to be provided with every generator to reduce its voltage to zero in the event of any open circuit occurring at any part in the system. This device is not to be applied to short circuit the generators.

(*b*) When more than one generator is fitted, each such machine is to be provided with a double-pole selector switch arranged to connect the generator in series with the system or alternatively to isolate the generator by :—

(i) Short circuiting the machine after reducing its voltage to zero.
(ii) Completing the continuity of the circuit.
(iii) Disconnecting the machine.

(*c*) All distribution switches are to be capable of effecting the same operations as the generator selector switches (*see* clause (*b*) above).

(*d*) Every current-consuming device is to be provided with a main switch, which is to isolate the device from the system without breaking the main circuit.

(*e*) Every motor is to be provided with a by-pass switch which is to automatically short circuit the motor terminals when its armature is at rest and the controller is at zero speed position.

4. **Earthing.**—No part of the system is to be earthed.

Section 21.

ELECTRO-MAGNETIC COUPLINGS.

1. **General.**—In ships in which power for propulsion purposes is transmitted either wholly or partially by means of electro-magnetic couplings they are to be constructed under special survey and tested in the presence of the Surveyors.

2. **Plans.**—In order to facilitate the inspection, plans in triplicate are to be submitted for consideration before the work is commenced. The plans are to show the scantlings and construction of the main units intended for the transmission of power and details of the electrical components, switchgear and control gear.

3. **Rating, Construction and Installation of Couplings.**—The relevant requirements of Section 12 Electric Motors are to apply as far as they are applicable to electro-magnetic couplings.

4. **Discharge Protection.**—Effective means are to be provided for limiting the induced voltage when field circuits are opened, in order to protect the field windings and associated cables, switchgear and control gear and the main busbars.

5. **Magnetic Air Gaps.**—Provisions are to be made to facilitate the periodical checking of the magnetic air gap, and gauges are to be supplied for this purpose. The estimated out-of-balance pull due to eccentricity of the air gap is to be stated when submitting the plans for consideration.

6. **Mechanical Protection.**—Adequate protection is to be provided to prevent the ingress of foreign bodies, particularly of magnetic material.

7. **Magnetic Centre.**—The position of magnetic centre is to be pre-determined and the couplings are to be assembled in the ship in correct position so that there is no appreciable axial thrust between the two halves of the coupling when in service.

8. **Testing.**—Unless otherwise approved, every coupling is to be tested at the maker's works in the presence of the Surveyors.

The tests are to include :—

(*a*) Temperature tests at such speed or speeds, and with torques corresponding with the estimated service torques, as may be approved to ensure conformity with the prescribed limits of temperature rise.

(*b*) An overspeed test for three minutes at a speed 25 per cent. above the maximum service speed.

(*c*) Determination of magnetic centre.

(*d*) Insulation resistance.

(*e*) High voltage test.

Section 22.

SUPPRESSION OF RADIO INTERFERENCE.

1. **General.**—Where measures are taken to suppress interference with radio services components fitted to circuits, apparatus, motors or generators employed on essential services are to comply with the following clauses 2 to 4 inclusive.

2. Components other than capacitors are to be suitable for use under tropical conditions, salt-laden atmospheres and in a cooling air temperature of 45° C. (113° F.) in machinery spaces and 40° C. (104° F.) elsewhere. Where they are fitted in machines or appliances they are to be suitable for the temperatures which prevail in such apparatus under working conditions, whether due to direct radiation from the windings, from the heated air, or by thermal conduction.

3. Capacitors are to be suitable for continuous working in surroundings having ambient temperatures between −40° C. (−40° F.) and 85° C. (185° F.) and in atmospheres of 100 per cent. relative humidity. The voltage rating of the capacitor is to be not less than the normal voltage to which it will be subjected to in service and is to be such that this voltage causes no deterioration in its electrical properties.

The terminal insulation is to be such as to have long life with continuous use, terminals which do not use organic materials being preferred. The creepage distance between any two terminals over an exposed surface or between any terminal and an exposed conducting surface such as the case of the capacitor, if metallic, is to be not less than the following :—

(*a*) Over the surface of insulant ... $(2+\frac{U}{250})$ mm.

(*b*) Across an air gap ... ... $(2+\frac{U}{500})$ mm.

Where U is the rated voltage of a D.C. rated capacitor or $U=\sqrt{2}E$ in the case of A.C. rated capacitors, E being the R.M.S. voltage. Fractions of a millimetre are to be counted as one mm.

Any impregnating or filling compounds are to be of a substantially non-polar nature, i.e., shall have a dielectric constant not exceeding 3·0.

Paper dielectric capacitors are to have at least three layers of paper separating the electrodes, each layer of a nominal thickness not less than 9·0 microns, and the working stress, defined as the rated voltage (or 1·41 times the R.M.S. voltage in the case of A.C.) divided by the total nominal thickness of the dielectric, is not to exceed 8·5 volts per micron.

Containers and terminal entries are to be such that they remain permanently hermetically sealed and are to be corrosion-proof under working conditions.

The insulation resistance between terminals corrected to 20° C. is to be not less than 5,000 ohm-farads for capacitors of 0·1 microfarads and over and not less than 50,000 megohms for capacitors less than 0·1 microfarads. (Ohm-farads will be the product of the insulation resistance in megohms and the capacitance in microfarads.)

The insulation resistance between terminals and adjacent conducting surfaces in metal-cased capacitors in which the case is not electrically connected to an electrode is to be not less than 1,000 megohms when tested at 500 volts D.C.

All capacitors are to withstand without detriment the application of a D.C. voltage equal to 6U in the case of capacitors for D.C. use or 8·5E for A.C. use applied between terminals and also between terminals and case, if of metal, and insulated from the electrodes for not less than one nor more than five seconds.

4. Where capacitors are fitted to the main busbars, emergency generators or steering gear, fuses of appropriate category are to be connected in the capacitor circuit.

Section 23.

TRIALS.

1. **General.**—Before a new installation or alterations or additions to an existing installation are put into service, the appropriate trials specified in clauses 2 to 12 inclusive are to be made. Such trials are to be in addition to, and not in substitution for, the acceptance trials of the individual items of plant at the makers' works.

2. **Testing Voltage.**—(*a*) The voltage used for the insulation-resistance tests referred to in clauses 3 to 7 inclusive is to be direct-current voltage not less than twice that to which the circuits will normally be subject (twice the root-mean-square value if the supply is alternating-current), provided that it need not exceed 500 volts for circuits normally not exceeding 650 volts.

(*b*) When the insulation-resistance of an installation or section of an installation is found by a 500-volt instrument to be below 0·5 megohm, the installation is to be so sub-divided, for the purposes of the test, that the insulation-resistance of each section is not less than 0·5 megohm.

3. **Insulation Resistance of Completed Installation.**—Before a completed installation, or an addition to an existing installation, is put into service, the insulation resistance to earth of every distribution circuit is to be not less in megohms than 50 divided by the number of outlets (points and switches) from the fixed wiring, except that it need not exceed 1 megohm. The test is to be made with all fuse-links in place, all switches (except the supply switch) closed, and, except with systems having one pole of the supply permanently earthed, all lamps in position or both poles of the installation otherwise electrically connected together.

4. **Switchboards.**—Before a main switchboard, emergency switchboard, or section board, is put into service, the insulation resistance is to be not less than one megohm, when measured :—

(i) between each insulated busbar and earth.

(ii) between each insulated busbar and the busbar connected to the other pole or poles.

The test is to be made with all circuit-breakers and switches in the open position and all fuse-links for pilot lamps, earth lamps, voltmeters, etc., removed. Voltage coils normally connected to the busbars are to be temporarily disconnected while the test between poles is being made.

5. **Heating and Power Appliances.**—During the test of any circuit, control rheostats and heating and power appliances normally connected to the circuit may, if desired, be disconnected; but in that event the insulation resistance between the case and/or framework and all live parts of every rheostat and appliance is to be not less than half a megohm.

6. **Testing between Conductors.**—Where practicable, the insulation resistance is also to be measured between all the conductors connected to each pole of the supply and all the conductors connected to the other pole or poles or to the "middle wire" or the "neutral"; and its value is not to be less than that specified in clause 3.

7. **Testing Polarity of Fuses and Single-Pole Switches.**—Precautions are to be taken to verify that no fuse, non-linked switch, or non-linked circuit-breaker, has been connected to that pole of a circuit which is either earthed or derives its polarity from an earthed conductor.

8. **Testing Earth Continuity.**—(*a*) Where lead-alloy-sheathed cables or armoured cables are employed, tests are to be made where necessary to verify that all metallic envelopes are electrically continuous throughout their length, and are earthed as required by Section 9, clause 5 (*f*).

(*b*) Tests shall be made to verify that all earth continuity conductors and earthing leads are connected to the frames of the fittings and appliances, and to the hull of the ship, and that in socket-outlets having earthing contact-tubes, the latter are also connected to the hull.

9. **Insulation Resistance of Generators and Motors.**—(*a*) The insulation resistance in megohms of every completed generator and motor in normal working condition and with all parts in place is not to be less than

$$\frac{3 \times \text{Rated Voltage of Machine}}{1{,}000 + \text{Rated Output of Machine in kVA}}$$

All insulation tests are, where possible, to be made when the generators and motors are hot.

(*b*) The insulation resistance of generator cables, motor cables, field windings, and control gear, when isolated and separated for testing purposes, is not to be less than 1 megohm.

10. **Generating Sets, Switchgear and Connections.**—It is to be demonstrated that the relevant requirements of these Regulations have been complied with in respect of the following :—

(*a*) The satisfactory commutation and performance of every generator throughout a run at full rated load.

(*b*) The temperatures of all joints and connections, fuses, circuit-breakers, and busbars.

(*c*) The operation of engine speed governors, over-speed trips, generator reverse-current and over-current trips, preference trips and other safety devices.

(*d*) The voltage regulation of every generator, when full rated load is suddenly thrown off by operating the circuit-breaker or main switch (*see* Section 2, clauses 5 (*b*) and 5 (*d*).

(*e*) The satisfactory operation in parallel, load sharing, etc., of all generators capable of being run in parallel with a load on the busbars of not less than 1½ times the full load rating of the largest generator.

11. **Motors and Generators.**—Every motor (with its control gear) is to be run under service conditions for a sufficient length of time to demonstrate that its wiring, alignment, size, direction of rotation, speed, commutation and temperature, are satisfactory.

12. **Apparatus.**—All lamps, heaters and other appliances are to be run, though not necessarily under full load or simultaneously. Tests of voltage are to be made, if necessary, to verify compliance with Section 6, clause 9 (voltage drop).

Section 24.

SPARE GEAR.

In ships engaged in open sea service, the articles mentioned in the following list (so far as they are applicable) will be required to be carried, viz. :—

For the Generators.

For each size of generator :—

1 set of carbon brushes for one machine.
1 set of any special spanners required.

For the Motors.

For each size of motor engaged on essential services, such as those enumerated below :—

1 set of carbon brushes for one machine.
1 set of any special spanners required.

The following are motors for which spare gear is required :—

Auxiliary compressors.
Scavenge blowers.
Cooling water pumps for main engines.
Cargo refrigerating motors, including compressors, brine pumps, circulating pump, fans, etc.
Oil fuel pumps.
Fans for forced draught to boilers.
Condenser circulating pumps.
Air pumps.
Feed water pumps.
Fire pumps.
Bilge pumps.
Steering gear.
Windlasses.
Ventilating fans for engine room and boiler rooms.

For the Steering Gear.

For each size of steering gear motor and motor-generator, if no standby machine is installed, the following spare gear is required in addition to the spares for motors enumerated above.

1 spare armature of each size fitted, complete with shaft and half coupling.

1 spare field coil of each type fitted.

Where electric steering gear is fitted and there is no standby generator, similar spare gear is also to be provided for the generator.

For Fans for Refrigerating Equipment.

For electrically driven air circulating fans the following spare gear will be required:—

1 complete fan and motor of each size used.

For the Control Gear.

For the starting gear of motors, such as those enumerated above:—

1 set of contacts subject to burning or wear.

1 set of springs.

10 per cent of each different resistance element, but at least one of each.

1 of each type of shunt coil used for contactors, relays or low voltage release.

For six or less starters in which these parts are interchangeable it will be sufficient to provide one set of spares for the starter employing the greatest number of parts.

For the Switchgear and Distribution Boards.

For each type of circuit-breaker on each pole:—

1 set of contacts which are liable to be burnt or worn.

1 set of parts subject to wear.

1 set of springs.

1 shunt trip coil and 1 resistance element, of each kind used.

10 per cent but not less than 12 of each type of cartridge or other non-rewireable fusible cut-out.

Rewireable fuse-handles; 5 per cent, with a minimum of one, of each size or type used, provided that not more than 12 need be supplied.

For the Navigating and Signal Lights, and their pilot lamps for indicating devices:—

1 complete spare set of lamps.

Emergency Lighting.

Where there is supplied from storage batteries of a voltage different from the ship's circuit:—

1 complete spare set of lamps.

Mineral-Insulated Copper-Sheathed Cables.

Where ocean-going ships are wired to any appreciable extent with mineral-insulated copper-sheathed cables suitable spares are to be carried. Following is an indication of the type of spares required for an average installation:—

Description.	Suggested Quantity.
Insulating Ferrules.	Up to 12 of each size according to the quantity used and the size of the ferrule.
Insulating Sleeve.	Up to 4 ft. of each size and colour according to the quantity used.
Sealing Compound.	Six sticks and one ½-lb. tin.
Recessors and Recessor Holders.	One recessor and holder for each size of cable used.
Gland Seal Components.	Complete components of each size used, comprising Universal Gland, Ebonite Cap, Brass Collar and Locknuts to make up 4 gland seals of each size used. The gland parts and nuts should be drilled with pilot holes. The caps may be supplied plain or with pilot holes.
Compression Rings for Gland Seals.	Up to 6 of each size required for the sizes of cables used.
Cable.	In large installations spare lengths of cable may also be advisable.
Installation Instructions.	One copy of the maker's recommendations, preferably to be kept in the box of spares, if any.

Insulation Tester.

It is recommended that a 500 volt insulation tester be provided with all equipment of 100 kw. and above for the testing of insulation and tracing of faults and that all parts of the system be periodically tested and the results recorded.

Electro-Magnetic Couplings.

For each size of electro-magnetic coupling used for propulsion purposes, a list of spare gear for the couplings and their associated control gear is to be submitted for consideration.

This is to include the following as a minimum :—

1 field coil of each type fitted.

1 set of brushes for one coupling.

1 gauge for checking the magnetic air gap.

Spares for the control gear and switchgear as above.

Storage and Packing.

All spare electrical gear is to be suitably packed to resist deterioration and stored in dry situations.

Section 25.

PERIODICAL SURVEYS.

For periodical surveys see **Section 4, Periodical Survey Requirements, "Electrical Equipment."**

71, FENCHURCH STREET, LONDON, E.C.3.

20th May, 1948.

TABLE I.

Current Rating for Single- and Twin-Core Vulcanized-Rubber-Insulated Cables.*

Conductor.		Cooling-air Temperature up to 104° F. (40° C.).			Cooling-air Temperature up to 113° F. (45° C.).		
		Current Rating‡	Approximate Length in Circuit (*Lead plus Return*) for 1-volt Drop with Current Rating in Col. 3.		Current Rating‡	Approximate Length in Circuit (head plus return) for 1-volt Drop with Current Rating in Col. 7.	
Nominal Cross-Sectional Area.	Number and Diameter (in.) of Wires	Direct Current or Single-phase A.C.	Direct Current.	Single-phase Alternating Current.	Direct Current, or Single-phase Alternating Current.	Direct Current.	Single-phase A.C.
1.	2.	3.	4.	5.	6.	7.	8.
sq. in.		amps.	feet.	feet.	amps.	feet.	feet.
0·0015	1/·044	5	33	33	4	41	41
0·002	3/·029	5	42	42	4	53	53
0·003	3/·036	10	33	33	7	47	47
0·003	1/·064	10	35	35	7	50	50
0·0045	7/·029	15	33	33	11	45	45
0·007	7/·036	24	32	32	17	45	45
0·01	7/·044	31	37	37	22	52	52
0·0145	7/·052	37	43	43	27	59	59
0·0225	7/·064	46	53	53	33	73	73
0·03	19/·044	53	58	58	38	82	81
0·04	19/·052	64	68	67	46	94	93
0·06	19/·064	83	79	76	60	109	105
0·1	19/·083	118	93	87	85	130	121
0·15	37/·072	152	106	97	110	147	134
0·2	37/·083	184	117	97	133	161	135
0·25	37/·093	214	126	97	155	174	134
0·3	37/·103	240	138	99	174	190	136
0·4	61/·093	288	154	96	208	214	133
0·5	61/·103	332	164	89	240	227	123
		D.C. A.C.			D.C. A.C.		
0·75	91/·103	461 425	176	76	334 308	244	106
1·0	127/·103	595 520	191	68	430 376	264	94

‡ The current ratings in Table I are subject to the maximum permissible voltage drop (*See* Section 6, clauses 6 (*b*) and 9) not being exceeded. See also Appendix 9.

* Including cables with fire-resisting insulation ('R.N.N.' type), polychloroprene-compound-sheathed ('H.R.' type) cables and lead-alloy-sheathed cables; but excluding (for use with alternating-current) the cables prohibited under Section 6, clause 8 (*b*), i.e., single-core cables armoured with magnetic material.

Lloyd's Register of Shipping, London.—*20th May, 1948.*

TABLE I A.

CURRENT RATINGS FOR 3-CORE VULCANIZED-RUBBER-INSULATED CABLES.*

Conductor.		Cooling-air temperature up to 104° F. (40° C.)		Cooling-air temperature up to 113° F. (45° C.).	
Nominal cross-sectional area.	Number and diameter (in.) of wires.	Current rating† 3-phase A.C.	Approx. length in circuit (lead only) for 1-volt drop to neutral for balanced 3-phase A.C. with current rating in Col. 3.	Current rating† 3-phase A.C.	Approx. length in circuit (lead only) for 1-volt drop to neutral for balanced 3-phase A.C. with current rating in Col. 5.
1.	2.	3.	4.	5.	6.
sq. in.		amps.	feet.	amps.	feet.
0·002	3/·029	5	42	4	53
0·003	3/·036	10	33	7	47
0·003	1/·064	10	35	7	50
0·0045	7/·029	15	33	11	45
0·007	7/·036	17	45	12	64
0·01	7/·044	22	52	16	71
0·0145	7/·052	26	61	19	84
0·0225	7/·064	32	76	23	105
0·03	19/·044	37	84	27	115
0·04	19/·052	45	96	33	130
0·06	19/·064	58	111	42	154
0·1	19/·083	83	128	60	177
0·15	37/·072	106	141	77	194
0·2	37/·083	129	147	93	204
0·25	37/·093	150	150	109	206
0·3	37/·103	168	153	122	211
0·4	61/·093	202	150	146	208
0·5	61/·103	232	143	168	198

*Including cables with fire-resisting insulation ('R.N.N.' type) polychloroprene-compound sheathed ('H.R.' type) cables and lead alloy sheathed cables.

†The current ratings in Table I A are subject to the maximum permissible voltage drop (see Section 6, clauses 6 (*b*) and 9) not being exceeded. See also Appendix 9

LLOYD'S REGISTER OF SHIPPING, LONDON.—*20th May, 1948.*

TABLE II.

Current Ratings for Single-Core Impregnated Paper or Varnished Cambric, Insulated Cables* and Mineral-Insulated Copper Sheathed Cables.

Conductor.		Cooling-Air Temperature up to 104° F. (40° C.)			Cooling-Air Temperature up to 113° F. (45° C.)		
		Current Rating‡.	Approximate Length in Circuit (*Lead plus Return*) for 1-volt Drop with Current Rating in Col. 3.		Current Rating‡.	Approximate Length in Circuit (*Lead plus Return*) for 1-volt Drop with Current Rating in Col. 6.	
Nominal Cross-Sectional Area.	Number and Diameter (in.) of Wires.	Direct Current, or Single-phase A.C.	Direct Current.	Single-phase Alternating Current.	Direct Current, or Single-phase.	Direct Current.	Single-phase A.C.
1.	2.	3.	4.	5.	6.	7.	8.
sq. in.		amps.	feet.	feet.	amps.	feet.	feet.
0·0015	1/·044	5	31	31	5	31	31
0·002	3/·029	5	40	40	5	40	40
0·003	3/·036	10	31	31	10	31	31
0·003	1/·064	10	33	33	10	33	33
0·0045	7/·029	15	31	31	15	31	31
0·007	7/·036	30	24	24	27	26	26
0·01	7/·044	45	24	24	41	26	26
0·0145	7/·052	60	25	25	55	27	27
0·0225	7/·064	80	28	28	72	31	31
0·03	19/·044	92	31	31	84	34	34
0·04	19/·052	110	37	37	101	40	40
0·06	19/·064	143	43	42	130	47	46
0·1	19/·083	202	51	47	185	56	51
0·15	37/·072	260	58	53	238	63	58
0·2	37/·083	314	64	53	286	70	58
0·25	37/·093	363	69	55	331	76	61
0·3	37/·103	408	76	56	372	83	61
0·4	61/·093	492	84	56	448	93	62
0·5	61/·103	572	89	52	522	98	57
		D.C. A.C.			D.C. A.C.		
0·6	91/·093	660 625	94	50	605 572	102	54
0·75	91/·103	782 710	97	46	713 648	107	51
1·0	127/·103	987 842	107	43	900 768	118	47

* Excluding (for use with alternating current) the cables prohibited under Section 6, cla use 8 (*b*), *i.e.* single core cables armoured with magnetic material.

‡ The current ratings in Table II are subject to the maximum permissible voltage drop (*see* Section 6, clauses (*b*) and 9) not being exceeded. See also Appendix 9.

LLOYD'S REGISTER OF SHIPPING, LONDON.—*20th May, 1948.*

TABLE II A.

Current Rating for 3-Core Lead-Alloy-Sheathed Cables Insulated with Impregnated Paper or Varnished Cambric.

Conductor.		Cooling-air temperature up to 104°F. (40°C.).		Cooling-air temperature up to 113°F. (45°C.).	
Nominal cross-sectional area.	Number and diameter (in.) of wires.	Current rating† 3-phase A.C.	Approx. length in circuit (lead only) for 1-volt drop to neutral for balanced 3-phase A.C. with current rating in Col. 3.	Current rating† 3-phase A.C.	Approx. length in circuit (lead only) for 1-volt drop to neutral for balanced 3-phase A.C. with current rating in Col. 5.
1.	2.	3.	4.	5.	6.
sq. in.		amps.	feet.	amps.	feet.
0·003	3/·036	10	31	9	34
0·0045	7/·029	15	31	14	33
0·007	7/·036	21	34	19	38
0·01	7/·044	32	33	29	37
0·0145	7/·052	42	36	38	39
0·0225	7/·064	56	40	51	44
0·03	19/·044	64	45	58	50
0·04	19/·052	77	52	70	57
0·06	19/·064	100	60	91	66
0·1	19/·083	141	71	128	78
0·15	37/·072	182	78	166	86
0·2	37/·083	220	84	200	92
0·25	37/·093	254	87	231	96
0·3	37/·103	286	90	260	99
0·4	61/·093	344	90	313	99
0·5	61/·103	400	86	364	95

† The current ratings in Table II A are subject to the maximum permissible voltage drop (*see* Section 6, clauses 6 (*b*) and 9) not being exceeded. See also Appendix 9.

Lloyd's Register of Shipping, London.—*20th May, 1948.*

TABLE II B.

Current Rating for Single-core Varnished-Cambric-Insulated Polychloroprene (*e.g.* "Neoprene") Sheathed Cables.

Conductor.		Cooling-Air Temperature up to 104° F. (40°C.)			Cooling-Air Temperature up to 113° F. (45° C.)		
Nominal cross-sectional area.	Number diameter(in.) of wires.	Current Rating* D.C. or Single-phase A.C.	Approx. length in circuit (*lead plus return*) for 1-volt drop with current rating in Col. 3.		Current Rating* D.C. or Single-phase A.C.	Approx. length in circuit (*lead plus return*) for 1-volt drop with current rating in Col. 6.	
			D.C.	Single-phase A.C.		D.C.	Single-phase A.C.
1.	2.	3.	4.	5.	6.	7.	8.
sq. in.		amperes.	ft.	ft.	amperes.	ft.	ft.
0·007	7/·036	31	23	23	27	26	26
0·01	7/·044	41	26	26	36	30	30
0·0145	7/·052	48	31	31	42	35	35
0·0225	7/·064	61	37	37	53	42	42
0·03	19/·044	72	40	40	63	45	45
0·04	19/·052	88	46	46	77	52	52
0·06	19/·064	115	53	52	100	61	60
0·1	19/·083	161	64	59	141	73	67
0·15	37/·072	204	74	67	178	84	77
0·2	37/·083	246	82	68	215	93	77
0·25	37/·093	287	87	70	251	100	80
0·3	37/·103	326	95	70	285	108	80
0·4	61/·093	399	104	69	349	119	80
0·5	61/·103	458	111	65	400	128	74
		D.C. A.C.			D.C. A.C.		
0·6	91/·093	519 500	120	62	453 437	137	71
0·75	91/·103	594 565	128	58	519 494	147	67
1·0	127/·103	746 685	142	53	652 599	163	60

* The current ratings in Table II B above are subject to the maximum permissible voltage drop (*see* Section 6, clauses 6 (*b*) and 9) not being exceeded. See also Appendix 9.

Lloyd's Register of Shipping, London.—*20th May, 1948.*

TABLE III.

MAXIMUM PERMISSIBLE CURRENT* IN INTERMITTENTLY-LOADED CABLES.

Conductor.		Vulcanized-Rubber-Insulated Cables.		Impregnated-Paper-Insulated Cables and Varnished-Cambric-Insulated Cables.	
Nominal Cross-Sectional Area.	Number and Diameter (in.) of Wires.	Current for Half-hour Rating.	Current for One-hour Rating.	Current for Half-hour Rating.	Current for One-hour Rating.
1.	2.	3.	4.	5.	6.
sq. in.		amps.	amps.	amps.	amps.
0·0145	7/·052	38	37	60	57
0·0225	7/·064	47	46	79	75
0·03	19/·044	56	54	94	89
0·04	19/·052	68	65	113	105
0·06	19/·064	92	85	151	138
0·1	19/·083	142	124	225	199
0·15	37/·072	191	164	303	261
0·2	37/·083	247	204	376	320
0·3	37/·103	351	283	523	435
0·4	61/·093	452	357	663	543
0·5	61/·103	534	422	804	648
0·75	91/·103	774	604	1,180	930
1·0	127/·103	1,036	803	1,548	1,211

* The values in Table III are subject to the maximum permissible voltage drop (*see* Section 6, clause 9) not being exceeded. The approximate length in circuit (*Lead plus Return*) for 1 volt drop will be the corresponding length given in Tables I and II respectively multiplied by the continuous rating in amperes and divided by the intermittent rating.

TABLE IV.

CURRENT RATING AND RADIAL THICKNESS OF DIELECTRIC FOR TWIN FLEXIBLE CORDS AND FLEXIBLE CABLES.

Conductor.		Current Rating*	Approximate Length in Circuit (*Lead plus Return*) for 1-volt Drop with Current Rating in Col. 3.	Radial Thickness of Dielectric.	
Nominal Cross-Sectional Area.	Number and Diameter (in.) of Wires.			250-volt Cables.	660-volt Cables.
1.	2.	3.	4.	5.	6.
sq. in.		amps.	feet.	in.	in.
0·0006	14/·0076	2	53	0·033	—
0·001	23/·0076	3	59	0·034	—
0·0017	40/·0076	5	57	0·035	—
0·003	70/·0076	10	50	0·036	—
0·0048	110/·0076	15	48	0·038	—
0·007	162/·0076	20	48	0·039	—
0·01	97/·012†	25	49	0·043	0·060
0·0145	60/·018†	30	58	0·046	0·061
0·0225	91/·018†	37	70	0·049	0·062

* The current ratings in Table IV are subject to the maximum permissible voltage drop not being exceeded.

† For trailing cables and similar purposes.

LLOYD'S REGISTER OF SHIPPING, LONDON.—*13th April, 1939.*

TABLE V.

DIMENSIONS OF 250 VOLT VULCANIZED-RUBBER-INSULATED AND FIRE-RESISTING ('R.N.N.' TYPE) CABLES.

Conductors.		D. Minimum Thickness of Dielectric.	Minimum Thickness of Lead-Alloy Sheath.			Diameter of Armouring Wire Single Core.*	Minimum Thickness of "H.R." Sheath.		
Nominal Cross Sectional Area.	Number and Diameter (in.) of Wires.		Single Core.	Twin Core. Circular.	Three Core.† Circular.		Single Core.	Twin Core.	Three Core
1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
sq. in.		in.	in.	in.	in.	in.	in.	in.	in.
0·0015	1/·044	0·034	0·04	0·04	0·05	—	0·040	—	—
0·002	3/·029	0·036	0·04	0·04	0·05	0·048	0·040	0·055	0·055
0·003	1/·064	0·036	0·04	0·04	0·05	0·048	0·040	0·055	0·055
0·003	3/·036	0·038	0·04	0·04	0·05	0·048	0·040	0·060	0·060
0·0045	7/·029	0·039	0·04	0·05	0·06	0·048	0·040	0·060	0·060
0·007	7/·036	0·041	0·05	0·05	0·06	0·048	0·050	0·065	0·065
0·010	7/·044	0·043	0·05	0·05	0·07	0·048	0·050	0·065	—
0·0145	7/·052	0·046	0·06	0·06	0·07	0·048	0·055	0·065	—
0·0225	7/·064	0·049	0·06	0·06	0·07	0·048	0·055	0·065	—
0·030	19/·044	0·052	0·06	0·07	0·08	0·048	0·055	—	—
0·040	19/·052	0·056	0·06	0·08	0·09	0·064	0·060	—	—
0·060	19/·064	0·062	0·07	0·08	0·09	0·064	0·065	—	—

* For determining the sizes of Armouring Wire for Twin-Core, Three-Core and Multicore Cables see Table IX

† The thickness of lead-alloy sheath on Multicore Cables in which the Conductors are not of equal area is to be the same as that for a similar Cable having Conductors equal in area to that of the largest of the unequal Conductors.

D is the thickness of the dielectric as follows :—

(1) On the Conductor of Single-Core Cables.

(2) On each core of Twin and Three-Core Cables.

LLOYD'S REGISTER OF SHIPPING, LONDON.—*20th May, 1948.*

TABLE VI.

DIMENSIONS OF 660 VOLT VULCANIZED-RUBBER-INSULATED AND FIRE-RESISTING ('R.N.N.' TYPE) CABLES.

Conductors.		D. Minimum Thickness of Dielectric.	Minimum Thickness of Lead-Alloy Sheath.			Diameter of Armouring Wire Single Core.*	Minimum Thickness of "H.R." Sheath.		
Nominal Cross Sectional Area.	Number and Diameter (in.) of Wires.		Single Core.	Twin Core Circular.	Three Core† Circular.		Single Core.	Twin Core.	Three Core.
1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
sq. in.		in.	in.	in.	in.	in.	in.	in.	in.
0·0015	1/·044	0·055	0·05	0·05	0·06	0·048	0·040	—	—
0·002	3/·029	0·056	0·05	0·05	0·06	0·048	0·040	0·060	0·060
0·003	1/·064	0·057	0·05	0·05	0·06	0·048	0·040	0·060	0·065
0·003	3/·036	0·057	0·05	0·05	0·06	0·048	0·050	0·065	0·065
0·0045	7/·029	0·058	0·05	0·06	0·07	0·048	0·050	0·065	0·065
0·007	7/·036	0·059	0·06	0·06	0·07	0·048	0·050	0·065	0·065
0·01	7/·044	0·060	0·06	0·06	0·08	0·048	0·055	0·065	—
0·0145	7/·052	0·061	0·06	0·07	0·08	0·048	0·055	0·065	—
0·0225	7/·064	0·062	0·06	0·07	0·08	0·048	0·055	0·065	—
0·03	19/·044	0·062	0·06	0·07	0·08	0·048	0·060	—	—
0·04	19/·052	0·063	0·06	0·08	0·09	0·064	0·060	—	—
0·06	19/·064	0·065	0·07	0·08	0·09	0·064	0·065	—	—
0·1	19/·083	0·072	0·07	0·09	0·10	0·064	0·065	—	—
0·15	37/·072	0·080	0·08	0·09	0·10	0·080	0·065	—	—
0·2	37/·083	0·088	0·08	0·10	0·11	0·080	0·070	—	—
0·25	37/·093	0·095	0·09	0·11	0·12	0·080	0·070	—	—
0·3	37/·103	0·102	0·09	0·12	0·13	0·104	0·070	—	—
0·4	61/·093	0·114	0·10	0·13	0·14	0·104	0·080	—	—
0·5	61/·103	0·121	0·11	0·14	0·15	0·104	0·085	—	—
0·75	91/·103	0·131	0·12	—	—	0·104	0·100	—	—
1·0	127/·103	0·141	0·12	—	—	0·104	0·110	—	—

* For determining the sizes of Armouring Wire for Twin-Core, Three-Core and Multicore Cables see Table IX.

† The thickness of lead on Multicore Cables in which the Conductors are not of equal area is to be the same as that for a similar Cable having Conductors equal in area to that of the largest of the unequal Conductors.

D is the thickness of the dielectric as follows:—

(1) On the Conductor of single Conductor Cables.

(2) On each core of Twin and Three-Core Cables.

TABLE VI A.

DIMENSIONS OF 250 VOLT VULCANIZED RUBBER-INSULATED, TOUGH-RUBBER-SHEATHED CABLES.

Conductors.		Minimum thickness of Dielectric.	Minimum thickness of Tough Rubber Sheath.		
Nominal cross-sectional area.	Number and diameter (in.) of wires.		Single	Twin Core Circular.	Three-core Circular
1.	2.	3.	4.	5.	6.
sq. in.	in.	in.	in.	in.	in.
0·0015	1/·044	0·034	0·050	0·050	0·050
0·002	3/·029	0·036	0·050	0·060	0·060
0·003	3/·036	0·038	0·050	0·060	0·060
0·0045	7/·029	0·039	0·050	0·060	0·060
0·007	7/·036	0·041	0·050	0·060	0·060

LLOYD'S REGISTER OF SHIPPING, LONDON.—*20th May, 1948.*

TABLE VI B.

DIMENSIONS OF 660 VOLT VULCANIZED RUBBER-INSULATED, TOUGH-RUBBER-SHEATHED CABLES.

Conductors.		Minimum thickness of Dielectric..	Minimum thickness of Tough Rubber Sheath.		
Nominal cross-sectional area.	Number and diameter (in.) of wires.		Single.	Twin Core Circular.	Three-core Circular.
1.	2.	3.	4.	5.	6.
sq. in.	in.	in.	in.	in.	in.
0·0015	1/·044	0·055	0·05	0·06	0·06
0·002	3/·029	0·056	0·05	0·06	0·06
0·003	3/·036	0·057	0·05	0·06	0·06
0·0045	7/·029	0·058	0·05	0·06	0·06
0·007	7/·036	0·059	0·05	0·06	0·06

LLOYD'S REGISTER OF SHIPPING, LONDON.—*20th May, 1948.*

TABLE VI C.

Dimensions of Vulcanized-Rubber Insulated Cables for Communication Circuits.

Conductor.		Number of Pairs of Conductors.	Minimum Thickness of Dielectric.	Minimum Thickness of Lead Alloy Sheath.	Minimum Thickness of Polychloroprene Sheath ('H.R.' type).
Nominal Cross-sectional Area.	Number and Diameter (in.) of wires.				
1.	2.	3.	4.	5.	6.
sq. in.			in.	in.	in.
0·001	1/·036	1	0·034	0·04	0·05
0·001	1/·036	Quad	0·034	0·05	0·055
0·001	1/·036	3	0·034	0·06	0·065
0·001	1/·036	4	0·034	0·07	0·065
0·001	1/·036	7	0·034	0·07	0·065
0·001	1/·036	11	0·034	0·08	0·07
0·001	1/·036	15	0·034	0·09	0·07
0·001	1/·036	19	0·034	0·09	0·07

Lloyd's Register of Shipping, London.—*20th May, 1948.*

TABLE VII.

DIMENSIONS OF 660 VOLT CABLES — PAPER INSULATED OR VARNISHED CAMBRIC INSULATED.

Conductor.		Minimum Thickness of Dielectric.		Minimum Thickness of Lead Alloy Sheath.		Diameter of Armouring Wire Single Core.*
Nominal Area.	Number and Diameter (in.) of Wires.	D.	E.	Single Core.	Three Core.† (belted)	
1.	2.	3.	4.	5.	6.	7.
sq. in.	in.	in.	in.	in.	in.	in.
0·007	7/·036	0·07	0·055	0·06	0·06‡	0·064
0·0145	7/·052	0·07	0·055	0·06	0·06‡	0·072
0·0225	7/·064	0·07	0·055	0·06	0·06§	0·072
0·04	19/·052	0·07	0·055	0·06	0·06	0·072
0·06	19/·064	0·07	0·055	0·06	0·06	0·072
0·1	19/·083	0·07	0·055	0·06	0·06	0·072
0·15	37/·072	0·07	0·055	0·06	0·07	0·072
0·2	37/·083	0·07	0·055	0·07	0·07	0·080
0·25	37/·093	0·08	0·06	0·07	0·08	0·080
0·3	37/·103	0·08	0·06	0·07	0·08	0·080
0·4	61/·093	0·09	0·07	0·08	0·09	0·104
0·5	61/·103	0·09	0·07	0·08	0·10	0·104
0·6	91/·093	0·09	0·08	0·09	0·11	0·104
0·75	91/·103	0·10	0·09	0·09	0·12	0·128
1·0	127/·103	0·10	0·09	0·10	0·13	0·128

* For determining the sizes of the Armouring Wire for Three-Core Cables see TABLE IX.

D is the thickness of dielectric between Conductors in a multicore cable.

E is the thickness of dielectric between any one Conductor and the sheath in multicore cables or between the Conductor and sheath in a single-core cable.

† Shaped Conductors unless otherwise indicated.

‡ Circular Conductors.

§ Circular or Shaped Conductors.

LLOYD'S REGISTER OF SHIPPING, LONDON.—*20th May, 1948.*

TABLE VII A.

DIMENSIONS OF 660 VOLT VARNISHED CAMBRIC-INSULATED, POLYCHLOROPRENE-SHEATHED, BRAIDED AND COMPOUNDED CABLES.

Conductor.		Minimum thickness of Dielectric.		Minimum thickness of Polychloroprene Sheath.	
Nominal area.	Number and Diameter (in.) of wires.	D.	E.	Single Core.	Three Core†
1.	2.	3.	4.	5.	6.
sq. in.	in.	in.	in.	in.	in.
0·007	7/·036	0·07	0·055	0·08	0·08‡
0·0145	7/·052	0·07	0·055	0·08	0·08‡
0·0225	7/·064	0·07	0·055	0·08	0·08§
0·04	19/·052	0·07	0·055	0·08	0·08
0·06	19/·064	0·07	0·055	0·08	0·08
0·1	19/·083	0·07	0·055	0·08	0·08
0·15	37/·072	0·07	0·055	0·08	0·09
0·2	37/·083	0·07	0·055	0·09	0·09
0·25	37/·093	0·08	0·06	0·09	0·10
0·3	37/·103	0·08	0·06	0·09	0·10
0·4	61/·093	0·09	0·07	0·10	0·11
0·5	61/·103	0·09	0·07	0·10	0·12
0·6	91/·093	0·09	0·08	0·11	—
0·75	91/·103	0·10	0·09	0·11	—
1·0	127/·103	0·10	0·09	0·12	—

† Shaped conductors unless otherwise indicated.

‡ Circular conductors.

§ Shaped or circular conductors.

D is the thickness of dielectric between conductors in a multicore cable.

E is the thickness of dielectric between any one conductor and the sheath in multicore cables or between the conductor and sheath in a single core cable.

LLOYD'S REGISTER OF SHIPPING, LONDON.—*20th May, 1948.*

TABLE VIII.

Dimensions of 3,300 Volt Impregnated Paper Insulated or Varnished Cambric Insulated Cables.

Nominal Area of Conductor.	Minimum Thickness of Dielectric. D. (*See note below*).	Minimum Thickness of Lead-Alloy Sheath.	
		Single Core.	Three Core. (Shaped Conductors.)
1.	2.	3.	4.
PAPER INSULATED.			
sq. in.	in.	in.	in.
0·0225	0·11	0·06	0·06
0·04	0·11	0·06	0·06
0·06	0·11	0·06	0·07
0·1	0·11	0·07	0·07
0·15	0·11	0·07	0·08
0·2	0·11	0·07	0·08
0·25	0·11	0·07	0·08
0·3	0·11	0·08	0·09
0·4	0·12	0·08	0·10
0·5	0·13	0·09	0·10
0·6	0·14	0·09	—
0·75	0·15	0·10	—
VARNISHED CAMBRIC INSULATED.			
0·0225	0·13	0·06	0·06
0·04	0·13	0·06	0·06
0·06	0·13	0·06	0·07
0·1	0·13	0·07	0·07
0·15	0·13	0·07	0·08
0·2	0·13	0·07	0·08
0·25	0·13	0·08	0·09
0·3	0·13	0·08	0·09
0·4	0·14	0·08	0·10
0·5	0·14	0·09	0·11
0·6	0·15	0·09	—
0·75	0·17	0·10	—

Notes.—D is the thickness of the dielectric as follows:—

(1) Single-Core Cables: Between the Conductor and Metallic Sheath.

(2) Three-Core Cables: Between the Conductors and between any Conductor and Metallic Sheath.

Lloyd's Register of Shipping, London.—*20th May, 1948.*

TABLE IX.

SIZES OF GALVANIZED STEEL WIRE AND THICKNESS OF BEDDING FOR SINGLE-WIRE ARMOURING.

Nominal Diameter of Cable over Lead Alloy Sheath.		Nominal Diameter of Galvanized Steel Wire.		Nominal Thickness of Bedding before the Armouring is applied.	
Above.	Up to and including.	Rubber Insulated Cables.	Paper or Varnished Cambric Insulated Cables.	Rubber Insulated Cables.	Paper or Varnished Cambric Insulated Cables.
1.	2	3.	4.	5.	6.
in.	in.	in.	in.	in.	in.
—	0·5	0·048	0·064	0·04	0·06
0·5	0·8	0·064	0·080	0·06	0·06
0·8	1·05	0·080	0·080	0·1	0·10
1·05	2·0	0·104	0·104	0·1	0·10
2·0	—	0·128	0·128	0·1	0·10

LLOYD'S REGISTER OF SHIPPING, LONDON.—*20th May, 1948.*

TABLE X.

MINIMUM INSULATION RESISTANCE VALUES FOR 250 VOLT AND 660 VOLT VULCANIZED-RUBBER-INSULATED CABLES.

Nominal Area of Conductor.	Number and diameter (in.) of wires (or equivalent strand in flexible cables).	Insulation resistance for 1,000 yards at 60° F. (15·6°C.)
1.	2.	3.
sq. in.		megohms.
0·001	1/·036	3,000
0·0015	1/·044	3,000
0·002	3/·029	2,400
0·003	3/·036	2,100
0·003	1/·064	2,100
0·0045	7/·029	2,000
0·007	7/·036	1,800
0·01	7/·044	1,600
0·0145	7/·052	1,500
0·0225	7/·064	1,300
0·03	19/·044	1,200
0·04	19/·052	1,100
0·06	19/·064	1,000
0·1	19/·083	950
0·15	37/·072	850
0·2	37/·083	850
0·3	37/·103	800
0·4	61/·093	750
0·5	61/·103	700
0·75	91/·103	650
1·0	127/·103	600

LLOYD'S REGISTER OF SHIPPING, LONDON.—*20th May, 1948.*

TABLE XI.

MAXIMUM SPACING OF CLIPS SECURING LEAD-ALLOY-SHEATHED, VULCANIZED-RUBBER-SHEATHED ("H.R." TYPE), OR ARMOURED CABLES.

Overall Diameter of Cable. 1.	Sheathed. 2.	Armoured. 3.
	inches.	inches.
Under 0·3 inch ...	8	10
0·3 inch and under 0·5 inch	10	12
0·5 inch and under 0·75 inch	12	14
0·75 inch and under 1·25 inches ...	14	16
1·25 inches and above	16	18

TABLE XI A.

MAXIMUM SPACINGS OF CLIPS SECURING MINERAL-INSULATED COPPER-SHEATHED CABLES.

Overall Diameter	Clip spacing in inches	
	Horizontal.	Vertical.
Under 0·3 inch	12	16
0·3 inch and under 0·5 inch	15	20
0·5 inch and under 1·0 inch	18	24

TABLE XII.

APPROXIMATE CURRENT RATING OF FUSE-ELEMENTS COMPOSED OF TINNED COPPER WIRE OR STANDARD ALLOY* WIRE IN SEMI-ENCLOSED FUSES.

Current Rating	Tinned Copper Wire		Standard Alloy* Wire	
	Diameter	S.W.G.	Diameter	S.W.G.
1.	2.	3.	4.	5.
amps.	in.		in.	
1·8	—	—	0·0164	27
3·0	0·006	38	0·0240	23
5·0	0·0084	35	0·0320	21
8·5	0·0124	30	—	—
10·0	0·0136	29	—	—
15·0	0·020	25	—	—
17·0	0·022	24	—	—
20·0	0·024	23	—	—
24·0	0·028	22	—	—
30·0	0·032	21	—	—
37·0	0·040	19	—	—
46·0	0·048	18	—	—
53·0	0·048	18	—	—
60·0	0·056	17	—	—
64·0	0·056	17	—	—
83·0	0·072	15	—	—
100·0	0·080	14	—	—

NOTE.—The current ratings given in Table XII refer to the normal maximum current of the circuit and do not refer to the overload at which the fuse will operate.

The values of the currents given in Table XII are approximately those necessary to comply with Appendix 5 applied to the above fuse-elements used in semi-enclosed fuses. Where fuses are known to conform to this Appendix the size stated by the manufacturer on the case of the fuse should be adhered to in preference to that given in Table XII, if the fuse is loaded to its full capacity.

* The term "Standard alloy" refers to the eutectic tin-lead alloy (63 per cent tin, 37 per cent lead).

LLOYD'S REGISTER OF SHIPPING, LONDON.—*20th May, 1948.*

TABLE XIII.

STANDARD SIZES OF DIRECT CURRENT AND ALTERNATING CURRENT (3-PHASE) MOTORS WITH CORRESPONDING APPROXIMATE FULL-LOAD CURRENTS.

(*See* Section 6, clause 5(*c*) and Section 13, clause 9.)

Output of Motor	Direct-Current. Full-Load Current.		Three-Phase Alternating-Current. Full-Load Current.	
	110 Volts.	220 Volts.	230 Volts	415 Volts.
1.	2	3.	4.	5.
B.H.P.	Amps.	Amps.	Amps.	Amps
0·25	3·2	1·6	—	—
0·5	5·7	2·8	2·5	1·2
1·0	10	5·0	3·8	1·9
2·0	18	9·0	6·7	3·4
3·0	26	13	9·5	4·8
4·0	35	17	12	6·4
5·0	42	21	15	7·9
7·5	61	30	22	11·5
10	80	40	29	14·5
12·5	100	50	35	17
15	117	59	42	21
20	155	77	55	28
25	190	95	67	35
30	227	114	77	41
35	264	132	89	48
40	300	150	101	55
45	340	170	113	62
50	375	187	125	69
60	450	225	150	83
70	520	260	175	96
80	595	298	200	110
90	665	333	224	124
100	740	370	244	136
125	900	450	298	168
150	—	550	352	200

LLOYD'S REGISTER OF SHIPPING, LONDON.—*20th May, 1948.*

TABLE XIV.

CALCULATION OF MAXIMUM CURRENT WHICH WILL NORMALLY FLOW IN AN INSTALLATION TO A GROUP OF CARGO-WINCHES OR CRANES (FOR USE IN COMPUTING THE SIZES OF CABLES, SWITCHGEAR, ETC.). (*See* Section 6, clause 6 (*b*)).

Number of Winch Motors or Crane Motors supplied by the Circuit. 1.	Current to be provided for 2.
Two.	100% F.L. of the larger motor + 30% F.L. of the 2nd motor or 65% of the combined F.L. if the motors are of equal size.
Three.	100% F.L. of the largest motor + 25% F.L. of each of the remaining motors, or 50% of the combined F.L. if the motors are of equal size.
Four.	100% F.L. of the largest motor + 20% F.L. of each of the remaining motors, or 40% of the combined F.L. if the motors are of equal size.
Five.	100% F.L. of the largest motor + 20% F.L. of each of the remaining motors, or 36% of the combined F.L. if the motors are of equal size.
Six or more.	33% of the combined F.L. of the motors.

NOTE.—The letters "F.L." in Table XIV refer to the full-load current of the motor at its maximum brake-horse-power rating.

LLOYD'S REGISTER OF SHIPPING, LONDON.—*13th April, 1939.*

TABLE XV.

TEMPERATURE LIMITS FOR COILS OF CONTROL GEAR.

Insulating Material.	Total Temperature.		Maximum Temperature Rise [see Section 13, Clause 2(c)]	
	Shunt Coils.	Series Coils.	Shunt Coils.	Series Coils.
1.	2.	3.	4.	5.
Class O. Cotton, silk, paper, and similar materials, non-impregnated.	176°F. (80°C.)	194°F. (90°C.)	72°F. (40°C.)	90°F. (50°C.)
Class A. (1) Cotton, silk, paper, and similar materials when impregnated or oil immersed; also enamel used with any of the above	194°F. (90°C.)	212°F. (100°C.)	90°F. (50°C.)	108°F. (60°C.)
(2) Enamelled wire not in association with such fibrous material	230°F. (110°C.)	248°F. (120°C.)	126°F. (70°C.)	144°F. (80°C.)
Class B. Built up asbestos, mica, and similar materials and bare coils	284°F. (140°C.)	302°F. (150°C.)	180°F. (100°C.)	198°F. (110°C.)
Class D. Coils with synthetic resin impregnation	230°F. (110°C.)	248°F. (120°C.)	126°F. (70°C.)	144°F. (80°C.)

LLOYD'S REGISTER OF SHIPPING, LONDON.—*13th April, 1939.*

TABLE XVI.

LIMITS OF MAXIMUM PERMISSIBLE TEMPERATURE RISE FOR GENERATORS AND MOTORS OTHER THAN PROPULSION MACHINES INTENDED FOR MACHINERY SPACES IN OCEAN-GOING SHIPS AND SHIPS OPERATING IN TROPICAL WATERS.

Part of Machine	Temperature Rise ‡					
	Machines other than totally-enclosed				Totally-enclosed Machines.	
	Class A material		Class B material		Class A material	Class B material
	By Thermometer	By Resistance	By Thermometer	By Resistance	By Thermometer	By Thermometer
1. Alternating current windings of stators or rotors	63° F. (35° C.)	72° F. (40° C.)	81° F. (45° C.)	108° F. (60° C.)	81° F. (45° C.)	108° F. (60° C.)
2. Field windings stationary or rotating (other than 3, 4 and 5 below) ...	63° F. (35° C.)	81° F.† (45° C.)	81° F. (45° C.)	99° F.† (55° C.)	81° F. (45° C.)	108° F. (60° C.)
3. Exciter field windings	63° F. (35° C.)	*	81° F. (45° C.)	*	81° F. (45° C.)	108° F. (60° C.)
4. Low resistance field windings of more than one layer or compensating windings	72° F. (40° C.)	*	90° F. (50° C.)	*		
5. Single-layer field windings with exposed surface	81° F. (45° C.)	81° F. (45° C.)	108° F. (60° C.)	108° F. (60° C.)	81° F. (45° C.)	144° F. (80° C.)
6. Short-circuited windings insulated	81° F. (45° C.)	*	108° F. (60° C.)	*		
7. Windings of armatures having commutators	63° F. (35° C.)	*	81° F. (45° C.)	*	81° F. (45° C.)	108° F. (60° C.)
8. Commutators	72° F. (40° C.)				90° F. (50° C.)	
9. Slip rings (open)	72° F. (40° C.)				90° F. (50° C.)	
10. Slip rings (enclosed)	90° F. (50° C.)				99° F. (55° C.)	

* This method of measurement is not recognised in these cases.

† This method is not recognised in the case of direct-current machines.

‡ Based on a temperature of cooling air not exceeding 113° F. (45° C.). *See* Section 2, Clause 4, and Section 12, Clause 3.

LLOYD'S REGISTER OF SHIPPING, LONDON.—*20th May, 1948.*

TABLE XVII.

LIMITS OF MAXIMUM PERMISSIBLE TEMPERATURE RISE FOR GENERATORS AND MOTORS, OTHER THAN PROPULSION MACHINES.

(*a*) Not situated in the Machinery Spaces of ocean-going ships or of ships operating in tropical waters.
(*b*) Pipe-ventilated or water-cooled (*See* Section 2, Clause 2, and Section 12, Clause 1).
(*c*) For coasters, ferries and harbour craft operating solely outside the tropical belt.

Part of Machine	Temperature Rise ‡					
	Machines other than totally-enclosed.				Totally Enclosed Machines.	
	Class A material		Class B material		Class A material	Class B material
	By Thermometer	By Resistance	By Thermometer	By Resistance	By Thermometer	By Thermometer
1. Alternating current windings of stators or rotors	72° F. (40° C.)	81° F. (45° C.)	90° F. (50° C.)	117° F. (65° C.)	90° F. (50° C.)	117° F. (65° C.)
2. Field windings stationary or rotating (other than 3, 4 and 5 below) ...	72° F. (40° C.)	90° F.† (50° C.)	90° F. (50° C.)	108° F.† (60° C.)	90° F. (50° C.)	117° F. (65° C.)
3. Exciter field windings	72° F. (40° C.)	*	90° F. (50° C.)	*	90° F. (50° C.)	117° F. (65° C.)
4. Low resistance field windings of more than one layer or compensating windings	81° F. (45° C.)	*	99° F. (55° C.)	*		
5. Single-layer field windings with exposed surface	90° F. (50° C.)	90° F. (50° C.)	117° F. (65° C.)	117° F. (65° C.)	90° F. (50° C.)	153° F. (85° C.)
6. Short-circuited windings insulated	90° F. (50° C.)	*	117° F. (65° C.)	*		
7. Windings of armatures having commutators	72° F. (40° C.)	*	90° F. (50° C.)	*	90° F. (50° C.)	117° F. (65° C.)
8. Commutators	81° F. (45° C.)				99° F. (55° C.)	
9. Slip rings (open)	81° F. (45° C.)				99° F. (55° C.)	
10. Slip rings (enclosed)	99° F. (55° C.)				108° F. (60° C.)	

* This method of measurement is not recognised in these cases.

† This method is not recognised in the case of direct-current machines.

‡ Based on a temperature of cooling air not exceeding 104° F. (40° C.). *See* Section 2, Clause 4, and Section 12, Clause 3.

LLOYD'S REGISTER OF SHIPPING, LONDON.—*20th May, 1948.*

TABLE XVIII.

DIMENSIONS OF 660 VOLT MINERAL-INSULATED COPPER-SHEATHED CABLES.

Conductor.		Resistance per 1.000 yds. at 60°F.		Nominal thickness of dielectric	Nominal diameter over sheath.		
Nominal cross-sectional area	Nominal diameter	Nominal	Maximum allowable		Single-core	2-core	3-core
1	2	3	4	5	6	7	8
sq. in.	in.	ohms.	ohms.	in.	in.	in.	in.
0·0015	0·044	16	17	0·06	0·218	0·328	0·344
0·002	0·051	12	12·72	0·06	0·228	0·344	0·368
0·003	0·062	8	8·5	0·06	0·238	0·368	0·386
0·0045	0·076	5·33	5·65	0·06	0·254	0·397	0·422
0·007	0·094	3·43	3·64	0·06	0·272	0·437	0·453
0·01	0·113	2·4	2·54	0·06	0·290	0·469	0·516
0·0145	0·136	1·66	1·76	0·06	0·323	0·531	0·562
0·0225	0·169	1·07	1·13	0·06	0·349	0·594	0·641
0·03	0·196	0·8	0·85	0·06	0·386	0·656	0·720
0·04	0·226	0·6	0·64	0·06	0·422	—	—
0·06	0·276	0·4	0·42	0·06	0·484	—	—
0·1	0·356	0·24	0·255	0·06	0·578	—	—
0·15	0·436	0·16	0·17	0·06	0·672	—	—
0·2	0·506	0·12	0·127	0·06	0·75	—	—

NOTE.—The nominal diameters over sheath correspond to British Standard drill sizes for clearance holes and the cable will generally be between 0.002 in. and 0.007 in. less than the figures given.

LLOYD'S REGISTER OF SHIPPING, LONDON.—*20th May, 1948.*

APPENDICES Nos. 1, 2, 3, 4, 5, 6, 7, 8, 9 and 10.

IN CONNECTION WITH THE RULES FOR ELECTRICAL EQUIPMENT AND ELECTRIC PROPELLING MACHINERY.

APPENDIX 1.

BUSBARS AND CONNECTIONS.

1. **Material.**—The copper used is to have a conductivity for annealed copper not less than 99·25 per cent, and for medium hard and hard copper not less than 95 per cent of the International Standard for standard annealed copper.

2. **Joints.**—All joints between copper conductors are to be made after dip-tinning or coating with petroleum jelly, or have equally effective treatment for preventing deterioration of the joint.

All joints, whether soldered or not, are to have the parts mechanically secured together.

3. **Limits of Temperature Rise.**—The following temperature limitations, measured by thermometer or thermocouple, are to apply to bare conductors in contact with air, when carrying their full rated current.

(*a*) Conductors rated 2,000 amps. and below, maximum temperature 158° F.(70° C.). Maximum temperature rise 72° F. (40° C.).

(*b*) Conductors rated above 2,000 amps., maximum temperature 176° F.(80° C.). Maximum temperature rise 90° F. (50° C.).

4. **Thermal Expansion.**—Where necessary, provision is to be made to allow for expansion and contraction due to temperature variations.

5. **Clearance Distances.**—The clearance distances specified below apply only to busbars having no insulating covering other than the surrounding air, compound or oil.

Max. Rated Voltage between Phases or Poles.	Minimum Clearance to Earth.		Minimum Clearance between Phases or Poles.	
	In Air.	In Oil or Compound.	In Air.	In Oil or Compound.
	inches.	inches.	inches.	inches.
660	$\frac{5}{8}$	—	$\frac{3}{4}$	—
2,200	$1\frac{1}{2}$	—	$1\frac{1}{2}$	—
3,300	2	$\frac{1}{2}$	2	$\frac{3}{4}$
6,600	$2\frac{1}{2}$	$\frac{3}{4}$	$3\frac{1}{2}$	1

IMPORTANT NOTE.—The above figures do not apply to creepage distance along the surface of insulators or of insulating bases.

6. **Mechanical Strength.**—The busbars and connections are to be so proportioned and supported as to be capable of safely withstanding the maximum mechanical stresses to which they may be subjected by the initial value of the short circuit current.

APPENDIX 2.

INSULATING MATERIALS.

1. **Classification of Materials.**

A. For the purpose of these Rules the following International designations will apply.

Class O. Cotton, silk, paper and similar organic materials when neither impregnated nor immersed in oil.

Class A. Cotton, silk, paper and similar organic materials when impregnated or immersed in oil, also the substance known as enamel applied to enamelled wire.

NOTE.—Impregnated cotton, paper or silk (also compound treated insulation).—An insulation is considered to be "impregnated" when a suitable substance replaces the air between its fibres, even if this substance does not completely fill the spaces between the insulated conductors. The impregnating substance, in order to be considered suitable, must have good insulating properties, must entirely cover the fibres and render them adherent to each other and to the conductor, must not produce interstices within itself as a consequence of evaporation of the solvent or through any other cause, must not flow at the temperature limit specified, must not unduly deteriorate under prolonged action of heat.

Class B. Mica and asbestos and similar inorganic materials in built up form combined with binding cement. If *Class A* material is used in small quantities for structural purposes only, in conjunction with *Class B* insulation, the combined materials may be considered as *Class B*, provided the electrical and mechanical properties of the insulated winding are not impaired by the application of the temperature permitted for *Class B* material. (The word "impair" is here used in the sense of causing any change which could disqualify the insulating material for continuous service.)

Class C. Mica, without binding cement, porcelain, glass, quartz and other similar materials.

Class D. Coils insulated with synthetic resin impregnation.

B. **Insulation made up of Different Materials.**—When the insulation is made up of different materials (except in those cases defined under *Class B*) the temperature rise attained by each material is not to exceed the limit permitted for that material.

EXAMPLES.

(*a*) When the different insulating materials are used on various parts of one winding (for instance, in the slot and for the end windings) the limit of temperature rise applicable to any part of the winding is that set for the insulation used on the part.

(*b*) When the insulation on any part consists of superposed layers of insulating materials falling in different classes (for instance, superposed layers of *Class A* and *Class B* material) the two following cases arise.

(i) If it is possible to measure the temperatures attained by the various layers, each of the materials is entitled to the temperature rise which is assigned to it.

(ii) If it is not possible to measure the temperatures attained by the various layers, the temperature rise applicable to the part of the winding under consideration is to be taken as that for the insulating material with the lowest limit.

2. **Synthetic Insulating Boards, Tubes, etc., used for terminal boards and for mounting the live metal parts of switchgear and control gear.**—Material used for insulation slabs for switchboards, section boards, distribution fuse boards, terminal boards of apparatus and machines and similar applications is to be suitable for the purpose intended and is to be submitted for approval. Results of tests indicating the suitability of the material are to be submitted, the nature of which will depend on the application proposed. The materials are to be of first class quality and, where relevant approved National Standards exist, they are to comply with such standards. In general the tests should indicate the properties of the materials in relation to the following:—

A. INSULATION PROPERTIES.

(*a*) Surface insulation resistance.

(*b*) Surface breakdown.

(*c*) Di-electric strength.

These tests should preferably be carried out in an atmosphere of controlled temperature and humidity and, in certain cases, after immersing the sample in water.

B. WATER ABSORPTION.

C. MECHANICAL PROPERTIES.

D. HEAT RESISTANCE.

(*a*) Mechanical strength when heated within the limits of the working temperatures.

(*b*) Softening or tendency to flow or warp under combined heat and mechanical stress.

E. INFLAMMABILITY.— Self-extinguishing, non-inflammable or non-ignitable properties when heated by a Bunsen flame.

APPENDIX 3.

MOTORS AND GENERATORS FOR POWER AND LIGHTING SERVICES AND EXCITERS, BALANCERS AND BOOSTERS IN CONJUNCTION WITH ELECTRICAL PROPELLING MACHINERY.

1. **Overloads in Current and Torque.**—Generators and motors are to be capable of carrying, without injury, the following overloads in current and torque respectively after having attained the temperature rise corresponding to their rated load, the voltage and frequency being maintained at their rated values. Sustained overloads are not recognised for the following types of machines:—

(*a*) Totally enclosed.

(*b*) Short time rated.

MOTORS with continuous rating are to withstand the following overloads in torque.

(i) Sustained overloads:—

Sizes 10 B.H.P. and upwards per 1,000 r.p.m.	25 per cent for two hours.
Sizes 4 B.H.P. up to 10 B.H.P. per 1,000 r.p.m.	25 per cent for one half-hour.
Sizes below 4 B.H.P. per 1,000 r.p.m. ...	25 per cent for 15 minutes.

(ii) Momentary overloads:—

All sizes	50 per cent for one minute.
D.C. motors up to 150 B.H.P. per 1,000 r.p.m.	100 per cent for 15 seconds.
A.C. motors, all sizes.	100 per cent for 15 seconds.

GENERATORS with continuous rating are to withstand the following overloads in current.

(i) Sustained overloads:—

Sizes $7\frac{1}{2}$ Kw. or K.V.A. per 1,000 r.p.m. and upwards.	25 per cent for 2 hours.
Sizes 3 to $7\frac{1}{2}$ Kw. or K.V.A. per 1,000 r.p.m.	25 per cent for one half-hour.
Sizes below 3 Kw. or K.V.A. per 1,000 r.p.m.	25 per cent for 15 minutes.

(ii) Momentary overloads:—

All sizes	50 per cent for one minute.

NOTE.—The B.H.P. or K.V.A. per 1,000 r.p.m. $=$ $\frac{\text{Rated B.H.P. or K.V.A. (or Kw. if D.C.)} \times 1{,}000}{\text{Rated Speed.}}$

2. **Method of Temperature Measurement.**—The method to be used in any particular case is stated in clauses (*a*), (*b*) and (*c*) below.

(*a*) EMBEDDED TEMPERATURE DETECTORS (E.T.D.). This method is to be employed for the slot position of stator windings of the following types of machine:—

(i) Machines having a rated output of 5,000 K.V.A or more.

(ii) Machines having an axial core length of one metre or over.

(*b*) THERMOMETER METHOD. Mercury or alcohol bulb thermometers are to be employed, the latter being used where the magnetic field in the vicinity of the thermometers alternates or rotates. The temperatures are to be measured by thermometers applied to the hottest accessible surfaces of the stationary parts of the machine during the test period and other thermometers to the accessible surfaces of the rotating parts as soon as the machine is stopped after the test. The bulb of the thermometer, except at the point of contact, is to be covered with a pad of felt, cotton wool or other non-conducting material $\frac{1}{8}$ inch thick, extending at least $\frac{3}{4}$ inch in every other direction from the bulb and pressed into contact to prevent the loss of heat by radiation and convection from the bulb.

(*c*) RESISTANCE METHOD. The measurement of temperature rise by increase of resistance is applicable to all field windings (except stationary low resistance field windings and exciter field windings) and to stator windings not requiring the use of E.T.D. It is not to be used for the alternating current windings of machines requiring more than 5 minutes to come to rest. Resistance measurements are to be made before and at the conclusion of the temperature test.

(*d*) TEMPERATURE OF COOLING AIR.—The temperature of the cooling air for open type machines is to be measured by means of several thermometers at different points around and half way up the machine situated at distances of three to six feet away from it.

3. **Duration of Temperature Test.**—The temperature test for a machine having a continuous rating is to be of such duration that sufficient evidence is available to show that the temperature rise would not exceed the permissible limits were the test prolonged until a final steady temperature was reached. It is in no case necessary to prolong the test after a steady temperature rise has been reached. The duration of the temperature test for a machine having a short time rating is to be the time required for the rating.

4. **Temperature for a Machine having more than one Rating.**—When a machine has more than one rating, the temperature test is to be carried out at that rating which produces the greatest temperature rise. In cases where this cannot be determined beforehand, the machine is to be tested separately under each of its ratings.

5. **Commutation.**—A D.C. machine is to work with fixed brush setting from no load to the momentary excess current or torque specified and is to work sparklessly and without injury to the commutator or brushes from no load to the rated load and without injurious sparking or injury to the commutator or brushes up to the momentary excess current or torque specified. The commutation test is to be applied at the conclusion of the temperature test.

6. **Regulation.**—The voltage regulation test on generators and speed/load characteristics of motors are to be carried out at the conclusion of the temperature tests.

7. **High Voltage (Dielectric) Tests.**—The high voltage tests, in accordance with **Table II** below, are to be applied only to new and completed machines in normal working condition with all parts in place, at the makers' works, preferably at the conclusion of the temperature test. It is to be applied between the terminals and the frame with the core connected to the windings not under test. The test is to be made with alternating voltage of any convenient frequency between 25 and 100 cycles per second, of approximately sine-wave form. The test is to be commenced at a voltage of about one-third the test voltage and is to be increased to the full test voltage as rapidly as is consistent with its value being indicated by the

measuring instrument. The full test voltage is then to be maintained for one minute and then reduced to one-third of its full value before switching off.

TABLE II.
HIGH VOLTAGE TESTS.

ITEM NO.	MACHINE OR PART.	TEST VOLTAGE.
1.	Machines under 3 B.H.P./Kw./K.V.A. per 1,000 r.p.m.	1,000 v. + twice the rated voltage.
2.	Machines 3 B.H.P./Kw./K.V.A. and above per 1,000 r.p.m.	1,000 v. + twice the rated voltage—minimum 2,000 v.
3.	Field windings for synchronous generators when the excitation voltage does not exceed 750 v.	10 times the excitation voltage—minimum 2,000 v., maximum 3,500 v.
4.	Field windings for synchronous motors :	
	(*a*) when intended to be started up with the field windings short-circuited or connected across the exciter armature.	10 times the excitation voltage—minimum 2,000 v., maximum 3,500 v.
	(*b*) when intended to be started up with the field windings separated by a field dividing switch.	5,000 v.
	(*c*) when intended to be started up with the fields on open circuit and without a field-dividing switch.	5,000 v. when the excitation voltage is less than 275 v. 8,000 v. when the excitation voltage is equal to or exceeds 275 v.
5.	Field windings for synchronous motors when intended to be started up with A.C. windings idle.	As for 4(*a*).
6.	Exciter	Not less than that applied to the field windings of the machine to which it is connected, except when used with a synchronous machine intended to be started up from the alternating current side, in which case the test will be as given in Item 4(*a*) above.
7.	Secondary (rotor) windings of induction motors not permanently short-circuited.	For non-reversing motors :— 1,000 v. + twice the maximum voltage induced between slip rings. For reversing motors :— 1,000 v + four times the maximum voltage induced between the slip rings at standstill with full primary voltage applied to stator windings.

8. **Supplementary High Voltage (Dielectric) Tests.**—When for any reason it is desired to make additional high voltage tests on a machine which has already passed its tests in accordance with clause 8 above and when installed on site such additional high voltage tests are to be made in accordance with the requirements of clause 8, except that the voltage is to be 75 per cent of that specified above. Before the high voltage test is applied, the windings are to be cleaned and, if necessary, dried out.

9. **Insulation Resistance.**—The insulation resistance in megohms when the high voltage test is applied is not to be less than :—

$$\frac{3 \times \text{rated volts}}{1{,}000 + \text{rated output in K.V.A. or B.H.P.}}$$

The insulation resistance is to be measured with a D.C. voltage of about 500, preferably at the conclusion of the temperature test of the machine.

10. **Abbreviated Tests.**—In the case of duplicate machines up to 50 Kw./B.H.P. per 1,000 r.p.m. type tests of temperature rise, excess current and torque and commutation taken on a machine identical in rating and in all other essential details may be accepted in conjunction with abbreviated tests on each machine. For the abbreviated tests each machine is to be run and is to be found electrically and mechanically sound and in working order in all particulars, and is to have a high voltage (dielectric) test and insulation resistance test.

11. Motors intended for coupling to fans for the circulation of air in refrigerated cargo spaces are to be tested in accordance with the following :—

The Surveyor will witness a Type Test on the first motor of each size and type and Works Test Certificates are to be supplied for the remainder. This Type Test may also be accepted for repeat orders of motors identical in all essential respects provided cross references are given in the Works Test Certificates. Type Tests need not be carried out for motors of the same frame size as one previously tested for higher output.

Where motors are mounted in the air stream but are tested under "still air" conditions, generally two conditions may arise.

(i) The motor may be open at one or both ends when tested but totally enclosed when mounted in the air stream. In such cases a Type Test should be carried out under working conditions, i.e., in the trunking with the fan and fairings in place, or, alternatively, calculations furnished to verify that the Rules for temperature-rise are complied with.

(ii) The motor may be totally enclosed but with streamlined fairings. These may be accepted if, when tested in "still air," the temperature-rises are within the requirements of the Rules for totally enclosed motors, but if they are outside these requirements the procedure in (i) above will be followed.

APPENDIX 4.

MAIN ALTERNATORS, MOTORS AND DIRECT-CURRENT GENERATORS FOR ELECTRIC PROPULSION PURPOSES. (Continuous Maximum Rating.)

1. **General.**—Generators and motors for electric propulsion purposes are to conform in all respects to the requirements of Appendix 3, except as modified hereunder.

2. **Rating.**—The continuous maximum rating is the load which can be carried on test for an unlimited period without exceeding the specified limits of temperature rise.

3. **Limits of Temperature Rise.**—The following limits of temperature rise apply only to machines for electric propulsion purposes, having a maximum continuous rating, provided no sustained overloads are thrown upon it under normal service conditions.

TABLE I.

LIMITS OF PERMISSIBLE TEMPERATURE RISE.

ITEM.	PART OF MACHINE.	CLASS A MATERIAL.		CLASS B MATERIAL.			
		By Thermometer method. 1	By Resistance method. 2	By Thermometer method. 3	By Resistance method. 4	By E.T.D. (a) (see below) 5	By E.T.D. (b) (note below.) 6
1.	A.C. windings of stators or rotors.	81° F. (45° C.)	90° F. (50° C.)	99° F. (55° C.)	126° F. (70° C.)	126° F. (70°C)	108°F. (60°C)
2.	Field windings (other than 3, 4 & 5).	*	90° F. (50° C.)	*	126° F. (70° C.)	*	*
3.	Low resistance field windings of more than one layer, or compensating windings.	90° F. (50° C.)	*	108° F. (60° C.)	*	*	*
4.	Single layer field windings with exposed bare copper surface.	99° F. (55° C.)	99° F. (55° C.)	135° F. (75° C.)	135° F. (75° C.)	*	*
	Rotating field windings of high speed turbine driven alternators.	*	90° F. (50° C.)	*	144° F. (80° C.)	*	*
6.	Short circuit windings insulated.	99° F. (55° C.)	*	135° F. (75° C.)	*	*	*
7.	Windings of armatures having commutators.	81° F. (45° C.)	*	99° F. (55° C.)	*	*	*
8.	Short circuited windings un-insulated.	The temperature rise of these parts is in no case to reach such a value that there is a risk of injury to any insulating or other material on adjacent parts.					
9.	Iron core and other parts not in contact with windings.						
10.	Iron core and other parts in contact with windings.	The same limits of temperature rise as permitted for adjacent parts as given in Cols. 1 and 3 (or 2 and 4 in the case of Item 2).					
11.	Commutators	81° F. (45° C.).					
	Slip rings (open)	81° F. (45° C.).					
	Slip rings (enclosed) ...	90° F. (50° C.).					

(*a*) Between coils in one slot.
(*b*) Between outside of coil and bottom of slot.
* This method of measurement is not recognised in these cases.

4. **Excess Current and Torque**—(*a*) Generators are to be capable of withstanding on test for 15 seconds a current in amperes 50 per cent in excess of their rated current, the voltage being maintained as near the rated output as possible consistent with the maximum capacity of the prime mover. The exact value of the voltage is not important.

(*b*) Direct current motors are to be capable of withstanding on test for 15 seconds a torque 50 per cent in excess of that corresponding to their rating, the voltage being maintained at rated value.

(*c*) Synchronous motors are to be capable of withstanding for 15 seconds without dropping out of synchronism a torque 50 per cent in excess of the torque corresponding to their rating, the voltage and frequency of the A.C. system with which they are synchronised being maintained at their rated values and the excitation of the motor being maintained at the value required to meet the specified conditions at rated load.

(*d*) Induction motors are to be capable of withstanding for 15 seconds without stalling a torque 50 per cent. in excess of the torque corresponding to their rating, the voltage and frequency being maintained at their rated values.

5. **Short Circuit Test on Alternators.**—Alternators are to be capable of withstanding a momentary short circuit at the terminals of the machine applied when generating normal full rated voltage.

6. **Tests.**—All machines are to be tested at the manufacturers' works in the presence of the Surveyors. Where the machines are too large to carry out a temperature test at full load, proposals for equivalent tests are to be submitted for consideration. The high voltage and insulation tests and methods of temperature measurement are to be in accordance with Appendix 3.

Exciters and machines connected therewith, irrespective of rating, are also to be tested in the presence of the Surveyors.

APPENDIX 5.

FUSES.

1. **Current Rating.**—The current rating of a fuse is the current which the fuse will carry continuously without deterioration, and at which the specified temperature rise at any part does not exceed that specified in clause 6 below.

The term "fuse" includes all parts of the device, i.e., the fuse-element, contacts, carrier, base and terminals.

2. **Category of Duty.**—Approved fuses will be assigned for convenient reference a category of duty derived from the breaking capacity tests, and a fuse is not to be installed in any circuit having a prospective short circuit current in excess of that for which the fuse is assigned. The prospective short circuit current is the current which would flow through a short circuit applied to the supply terminals of the fuses under normal working conditions. The following categories of duty will be recognised as standard :—

Category of Duty.	Maximum Prospective Current of Test Circuit (amperes).
1	1,000
2	4,000
3	16,500
4	33,000

Fuses having a rated breaking capacity intermediate between these values will be assigned to the next lower category.

Fuses connected to the busbars of main switchboards, i.e., those busbars to which the generators are connected, are not to be used with generators having a greater total output under working conditions than that corresponding to the category of duty as shown in the following schedule :—

Category of Duty of Fuse.	Maximum Total Kw. Capacity of Generators under working conditions.		
	100–125 Volts D.C.	200–250 Volts D.C	3-phase 440 Volts A.C.
1	60	100	300
2	250	400	1,000
3	1,200	2,000	5,000
4	over 1,200	over 2,000	over 5,000

The fuses installed on section boards and distribution fuse boards will generally be of the same category of duty as on the main switchboard, but in special cases they may be of a lower category based on the prospective short circuit current at the position at which they are connected.

3. **General Construction.**—The contacts are to be so constructed and of such material that sufficient pressure is maintained under ordinary service conditions after repeated engagement and disengagement and when left untouched for long periods. Fuse links are to be such that overheating, arcing and scattering of hot metal or other substances is obviated. All non-metallic parts are to be constructed of non-ignitable, non-hygroscopic insulating material, provided that cartridges with their attached labels need not necessarily be non-ignitable, and that tubular linings, if any, enclosing fuse elements, linings of containing cases or covers, if any, and fillers of cartridges, need not of necessity be non-hygroscopic. The requirements of Section 3, clause 20, of the **Rules for Electrical Equipment** are to be complied with.

4. **Approval.**—In order to secure approval of fuses a report, preferably by an independent authority, is to be submitted for consideration, giving details of performance, fusing characteristics, temperature and insulation tests, and accompanied by outline drawings. The drawings should indicate the general arrangement and leading dimensions, including dimensions of contacts and terminals. Samples should not be submitted unless specially requested.

Fuses will be approved for standard direct current voltages up to 250, and alternating current voltages up to 440, and a list of approved fuses will be issued.

5. **Temperature Rise.**—Fuses are to be tested in surroundings free from external draughts and in the containing cases, if any, in which they may be used in service and in the position in which they will normally be mounted. The maximum temperature-rises of contacts and fixed terminals (or sweating sockets when used), at the top of fuses if mounted vertically, and of the connections, are to be measured by thermo-couples attached by means of low-melting-point alloy, or by some equally effective means of attachment.

The points at which the temperature-rises are measured are to be :—

(*a*) For contacts: the point at which the maximum temperature-rise may be expected to occur.

(*b*) For fixed terminals, or, when used, sweating sockets: the accessible point closest to the external connection.

(*c*) For connections: a point 1 ft. along the conductor from the corresponding terminal or sweating socket.

Appendix 5

Thermo-couples of copper-constantan attached by a low-melting-point alloy of equal parts of lead, tin, and bismuth are considered suitable.

After the fuses have carried their maximum rated current continuously for sufficient time to allow their temperatures to become steady the temperature-rise of the fuse-contacts is not to exceed 55° C., and of the fixed terminals (or sweating sockets when used) is not to exceed 46° C.

The conductors connected to fuses on test are to be of copper of uniform cross-section not greater than that shown below and are to be so disposed and covered, and/or lagged, that the temperature-rise at any point up to 1 ft. from the fixed terminal or sweating socket is not less than 85 per cent. of the actual temperature-rise on test of that terminal or sweating socket (when used).

Fuse rating.	Maximum size of Conductor.
amps.	sq. inches.
5	0·002
15	0·0045
30	0·007
60	0·0145
100	0·03
150	0·06
200	0·1

The covering and/or lagging is to be so applied that it is at least as thick over the portion of the connection within 1 ft. of the terminal as it is over any other portion.

6. **Performance (Breaking Capacity).**—Fuses are to be type-tested to ensure the satisfactory opening of the circuit when wired for their maximum current rating under conditions capable of producing the requisite prospective current according to the category of duty.

Fuses that are to be used in unlined metal cases are to be tested in bare metal cases having clearances from the fuse-parts not greater than the minimum clearances to be used in service. Fuses that are to be used in service without cases, or only in cases of insulating material, are to be tested in woven wire cloth enclosures having suitable clearances from the fuse-parts.

During the tests, metal cases and woven wire cloth wrappings are to be connected to earth through fine-wire fuses, wired with copper wire not greater than 0·0048 in. in diameter with a break not less than 3 in.

Fuses are to be tested for duty by testing single fuses in a single-phase A.C. circuit or in a D.C. circuit at not less than the voltage rating of the fuse. When tested in an A.C. circuit, the circuit is to be made at a rising voltage of 50 per cent. of the peak value, with a tolerance of plus or minus 15 per cent. of the peak value.

One pole of the test circuit is to be connected to earth, and in D.C. tests this is to be the negative pole. One terminal of the fuse to be tested is to be connected direct to that pole of the supply circuit which is not earthed.

The source of energy for the tests is to be capable of giving the required prospective currents and is to produce initially a recovery voltage not less than 90 per cent. and not more than 100 per cent. of the voltage rating of the fuse in A.C. tests and not less than 100 per cent. and not more than 110 per cent. of the voltage rating of the fuse in D.C. tests. If necessary, the test voltage may be increased initially above the voltage rating of the fuse in order to ensure that the recovery voltage will have the required value.

The frequency of supply for A.C. tests is to be 50 cycles per second plus or minus 25 per cent.

The impedance of an A.C. test-circuit, including, if required, a resistor and a reactor in circuit with the fuse, is to be appropriate to the required prospective current at a power-factor in accordance with the table below.

Category of Duty.	Maximum Prospective Current of test-circuit (amperes).	Power Factor (Lagging) not greater than	Time-constant (L/R) not less than
1	1,000	0·6	0·0030
2	4,000	0·4	0·0040
3	16,500	0·3	0·0100
4	33,000	0·3	0·0150

The resistance of a D.C. test-circuit, including, if required, a resistance in circuit with the fuse, is to be appropriate to the required prospective current, and the resistance and inductance of the circuit is to be such that the circuit has a time constant in accordance with the above table.

The recovery voltage is to be maintained at not less than 90 per cent. of the voltage rating of the fuse in A.C. tests and not less than 100 per cent. in D.C. tests for not less than 30 seconds immediately after the opening of the circuit by the fuse in order to prove that the fuse will withstand indefinitely continued application of its voltage rating.

The insulation-resistance between the terminals of the fuse-link is to be measured at the conclusion of the test.

Not less than three tests are to be made using the same fuse throughout, without the renewal of any parts other than fuse-elements and asbestos tubes or the like, if any, of semi-enclosed fuses, or fuse-links of cartridge-fuses.

Fuses are deemed not to comply with the requirements if, during one of these tests, any of the following failures occur:—

(*a*) Melting of the fine-wire fuse, indicating arcing to the metal case.

(*b*) Ignition of the fuses or ignition or damage of neighbouring apparatus, excluding any paper labels or the like used as indicating devices on the fuses.

(*c*) Mechanical damage sufficient to render any of the following parts unserviceable without repairs: fuse contacts, fuse carriers, fixed contacts, bases, cases or any other parts not intended to become unserviceable on the melting of the fuse-elements.

(*d*) In cartridge fuses, violent bursting of cartridges.

(*e*) Reduction of the insulation resistance between the terminals of the fuse-link to less than 100,000 ohms. when measured at 500 volts within 3 minutes after the conclusion of the test.

(*f*) A maximum arc-voltage greater than 2·5 kV.

The test certificate should state whether the test has been carried out with A.C. or D.C.

7. **Insulation Resistance.**—The insulation resistance measured

(*a*) between the fixed terminals, and

(*b*) between live parts and the containing metal case, if any, with all other parts in position except the fuse-element, is to be not less than 50 megohms.

8. **Marking.**—Fuse carriers intended for use with semi-enclosed fuse-links, or alternatively the containing cases, if any, of semi-enclosed fuses, and cartridges are to be indelibly marked with the maximum current rating (*see* **clause 1**) for which the fuses of which they form parts are suitable.

9. **British Standards.**—Fuses complying with the requirements of B.S.S. 88–1947 will be accepted as meeting the requirements of this Appendix, provided clauses 4 and 5 above are complied with.

APPENDIX 6.

FLAMEPROOF ENCLOSURE.

1. Where apparatus is required to be of the flameproof type and apparatus of suitable type is obtainable which has been type-tested and approved by a competent independent Testing Authority, such as, in the United Kingdom, the Ministry of Fuel and Power, for gases and vapours in Group II*, such apparatus only is to be used. Where such apparatus is not obtainable, the flameproof enclosure is to comply with the following requirements.

2. **Definition.**—A flameproof enclosure for electrical apparatus is one which will withstand, without injury, any explosion of the prescribed inflammable gas that may occur within it under practical conditions of operation within the rating of the apparatus (and recognised overloads, if any, associated therewith) and will prevent the transmission of flame such as will ignite the inflammable gas which may be present in the surrounding atmosphere.

NOTE.—Short of permanent hermetic sealing, which is generally impracticable, it must be assumed that any external explosive atmosphere may find its way within the enclosure and, moreover, that an ignitable atmosphere may be produced internally by the decomposition of oils, varnishes, rubber, etc. The term "gas-tight," therefore, has been deliberately discarded in favour of the term "flameproof."

3. **Construction.**—Where a certificate has been obtained from a recognised independent Testing Authority it will be sufficient to furnish a copy of the relevant certificate when required, provided there is no departure from the design so tested and approved.

* *See* Ministry of Fuel and Power Testing Memorandum No. 4.

Where suitable apparatus approved by a recognised competent Testing Authority as required by Clause 1 above is not obtainable it is to comply with the requirements of B.S. 229–1946 for gases and vapours in Group II, and full details of the construction are to be submitted for consideration before the work is commenced.

APPENDIX 7.

TINNING TEST.

A. Sodium-Polysulphide Tinning Test.

Any part of a tinned conductor removed from the core of the cable after the vulcanization process is complete is to satisfy the following tests :—

Samples of the tinned wire are to be selected and bent into circles, the diameter of the circles being between 24 and 30 times the diameter of the wire. After cleaning by immersion in benzine and rubbing with a pad of clean cotton wool or filter paper to remove any grease, the samples are to be dried in air and the part to be immersed in the test solution is not to be handled.

Each sample is then to be immersed in test solutions, as stated below, and maintained at a temperature of approximately 60° F. (15·6° C.). The cycle of operation is to be performed six times. Each cycle is to consist of :—

First : Immersion of the sample for one minute in hydrochloric acid, as defined below, the sample then being washed in clean water and wiped dry.

Second : Immersion of the sample for 30 seconds in sodium-polysulphide solution, as defined below, the sample then being washed in clean water and wiped dry.

The sample is then to be examined under a hand lens to ascertain if copper exposed through openings in the tin coating has been blackened by the action of the sodium-polysulphide. The sample is to be considered to have failed if, by such blackening, exposed copper is revealed.

In the event of only one sample of a set giving results widely dissimilar from the remaining samples discretion may be exercised with regard to this sample.

Testing Solutions. The hydrochloric acid solution is to have a specific gravity at 60° F. (15·6° C.) of 1·088.

A portion of hydrochloric acid solution having a volume of 180 ml. is to be considered to be exhausted when there has been immersed in it the following number of test-samples :—

DIAMETER OF WIRE.	Maximum number to be tested in 180 ml of acid solution.
Up to and including 0·044 in. ...	20
Above 0·044, up to and including 0·083 in.	12
Above 0·083 in.	8

The sodium-polysulphide solution is to have a specific gravity at 60° F. (15·6° C.) of 1·142 and is to be made in the following manner :—

Dissolve about 25 grammes of pure sodium-sulphide crystals in distilled water and make up to 100 ml., add powdered sulphur in excess of the quantity required to saturate the solution (about 25 grammes per 100 ml.), and boil for about one hour with occasional stirring.

Cool and filter the solution and then dilute with distilled water to a specific gravity of 1·142 at 60° F. (15·6° C.).

B. Persulphate Tinning Test.

As an alternative to the Sodium-Polysulphide Test the following may be used :—

1. Preparation of Test-Specimens.—(*a*) The insulation and coverings are to be removed from test samples of appropriate length (*see* Table) by any method which does not cause injury to the tin coating.

(*b*) Two groups of specimens, each comprising the number shown in column 4 of the Table, are to be marked 4 cm. from each end.

(*c*) Each specimen in the case of single conductors, or each group of 3 or 10 in the case of multiple conductors, is to be wound into one helix upon a smooth mandrel in such a manner as to ensure no twisting moment being imparted to the wire. Such portions as are necessary to lead up to the 4 cm. ends and provide for their projection above the

surface of the testing solution are not to be formed to the mandrel, but are to be suitably bent so as not to entail a radius less than half the diameter of the mandrel.

Test Samples.				Test Specimens.		
Diameter and number of wires comprising conductor.			Length	Number	Length between marks	
Diameter		Number			For each specimen	Total for each group
1		2	3	4	5	6
(in.)			(cm.)		(cm.)	(cm.)
0·0076		10 or more	58	10	50	500
Above	Up to and including					
0·0076	0.012	6 or more	108	5	100	500
0·012	0·029	3 or more	74·7	3	66·7	200
0·029	0·103	3 or more	41·3	3	33·3	100
0·029	0·103		108	1	100	100

(*d*) After the test-helix has been removed from the mandrel and immediately prior to its immersion in the test solution it is to be cleaned by immersion for 10 seconds in a suitable solvent, i.e., chloroform or methylated ether in one vessel followed by a similar immersion in a second vessel and allowed to to dry before immersion in the test solution.

In the event of rubber adhering to the test-specimen, the wire is to be cleaned before or after winding the test-helix by rubbing with a pad of cotton wool soaked in the solvent, or by treatment with hot solvent. In no case, however, is the test-helix to be straightened and re-wound or subjected to any serious mechanical deformation for the purpose of cleaning, and in all cases the double immersion described is to constitute the final cleaning operation.

2. **Preparation of Testing Solutions.**—The testing solutions are to be prepared as follows:—

(i) Persulphate Solution. Dissolve 10 grammes of fresh crystalline ammonium persulphate in distilled water, add 20 ml. of 0·880 ammonium hydroxide solution and make up to one litre with distilled water.

(ii) Standard Colour reagent. Dissolve 3·927 grammes of pure copper sulphate ($Cu\ SO_4\ 5H_2O$) and 50 ml. of 0·880 ammonium hydroxide solution in distilled water and make up to one litre with distilled water. One ml. of this solution is equivalent to 0·001 gramme copper.

3. **Immersion for Test.**—After cleaning, the helix is to be immersed for 10 minutes in the persulphate solution in such manner that the surface of the wire between the marks (*see* Column 5 in above Table) is exposed to the solution and the 4 cm ends project above the surface.

The test is to be carried out under normal room temperature conditions, but immediately prior to the immersion test the solution is to be brought to a temperature of 60° ± 2° F.

The volume of the solution is to be:—

Up to and including 0·072 in. dia. ... 75 ml.

Above 0·072 in. dia. ... ... 200 ml.

The diameters of the mandrels to be used are to be in accordance with the Table below.

Diameter of Wire (in.).		Diameter of Mandrel (in.).
0·0076		0·60
Above	Up to and including	
0·0076	0·01	0·65
0·01	0·012	0·70
0·012	0·018	0·85
0·018	0·029	1·15
0·029	0·036	1·30
0·036	0·044	1·50
0·044	0·052	1·70
0·052	0·064	2·0
0·064	0·072	2·2
0·072	0·083	2·5
0·083	0·093	2·75
0·093	0·103	3·0

4. **Determination of Weight of Copper dissolved.**—The weight of copper dissolved from the wire by the persulphate solution is to be determined colorimetrically by comparison with the standard colour reagent (*see* para. 2 (ii).). The weight is expressed as milligrammes of copper per square decimeter of wire immersed.

5. **Standard of Quality.**—If the result obtained does not exceed the appropriate value shown in the following Table the coating is to be regarded as satisfactory.

Diameter of wire (in.)		Milligrammes per square decimeter			
From	Up to and including	Ordinary Conductor Cables		Flexible Conductor Cables and Cords	
		Other than Tough-Rubber Sheathed	Tough-Rubber Sheathed	Other than Tough-Rubber Sheathed	Tough-Rubber Sheathed
1	2	3	4	5	6
0·0076	0·018	—	—	40	50
0·0181	0·103	30	30	30	30

If the result of one group exceeds the limiting value the test may be repeated from a fresh group comprised of specimens from the same cable from which the original defective group were taken, in order to ensure that the failure is not due purely to "end effect."

If this additional group also fails, the cable is to be rejected.

APPENDIX 8.

SPARK TESTING OF RUBBER INSULATED CABLES.

Spark testing can be applied to 250-volt and 660-volt Vulcanized Rubber Insulated Cables and fire-resisting polychloroprene insulated cables, flexible cables and flexible cords having conductors of a maximum cross-sectional area of 0·06 sq. in. as an alternative to insulation resistance and voltage tests.

The test is to be taken at the core stage, except for single-core, braided and compounded cable, in which case it may be taken at the finished stage as an alternative to the core stage.

The test electrode is to make intimate contact with the surface of the core or cable and shall preferably consist of a fine link mesh. The speed at which the core or cable passes through the electrode is to be such that every point is in the electrode for not less than 0·1 second.

The supply to the electrode is to be alternating current at 50 cycles per second. The conductor of the core or cable is to be earthed and the potential difference between the electrode and the conductor is to be in accordance with the following:—

Grade of Cable	R.M.S. Test Voltage
250-volt	Volts
Up to and including 0.0225 sq. in. ...	6,000
Above 0.0225 sq. in., up to and including 0.04 sq. in.	8,000
Above 0.04 sq. in., up to and including 0.06 sq. in.	10,000
660-volt	
Up to and including 0.04 sq. in.	10,000
Above 0.04 sq. in., up to and including 0.06 sq. in.	12,000

The detector is to be arranged so as to maintain fault indication even after the fault has passed out of the electrode.

The minimum sensitivity of the spark-testing apparatus is to be such that the detector will operate when an artificial fault device consisting of a spark gap in series with a capacitor is connected between the electrode and earth. The electrode potential is to be 6,000 volts R.M.S. and the capacitor 350 micro-microfarads. The spark gap is to consist of a metal plate moving past a needle point in 0·02 seconds, and the distance between them during this time is to be 0·2 inch. Check tests are to be taken at regular intervals.

APPENDIX 9.

CURRENT RATINGS OF CABLES.

1. The Tables apply to cables employed in the wiring of ships but do not provide for every condition under which cables may be used.

The current ratings and lengths set out are calculated for full-load conditions based on experimental data, and are based on maximum operating conductor temperatures of 124° F. (51° C.) for vulcanized-rubber insulated cables and 160° F. (71° C.) for lead sheathed impregnated-paper-insulated and varnished-cambric-insulated cables. They have been rounded off to apply, under practical conditions, to the respective cables and methods of installation defined in the Tables.

It is impracticable to specify ratings for every condition of grouping and of loading which may occur in ships, but guidance can be furnished for specific cases if desired.

The cooling air temperature referred to in the Tables is the temperature of the air under normal conditions, and does not take account of increase of temperature in the vicinity of cables due to heat arising therefrom.

2. The permissible ratings, subject to voltage drop, of cables run on cleats are generally higher than those run in clips, conduit or wood casings, and further particulars can be supplied on request.

3. In a three-phase system of single-core cables in flat formation passing through a steel bulkhead, each cable passing through a separate hole in steel, no direct effect need be anticipated on the current rating or voltage drop except in extremely short connections. Heating of the steel, however, results from the magnetic effects, the temperature rise at the hottest point amounting to twice the conductor temperature rise under unfavourable conditions. In confined spaces this may lead to increased cable temperatures unless a non-magnetic gland plate is used, non-magnetic glands or bushings giving at least $\frac{3}{8}$-in. clearance between the lead sheath and the steel should be used and the axial spacing between the cables should, where possible, be not less than 6 inches.

APPENDIX 10.

TRANSFORMERS FOR POWER AND LIGHTING.

1. Transformers, unless otherwise approved, are to be rated at their Continuous Maximum Rating expressed as the kVA output on non-inductive load when carrying rated current on the output side with rated voltage applied on the input side. This Appendix relates to transformers rated at 1 kVA or over if single-phase, and 5 kVA or over if polyphase.

2. The temperature rise, when tested at the Continuous Maximum Rating is not to exceed the limits given in the table below.

The temperature-rise limits specified for natural air cooling and air blast cooling, whether for dry or oil-immersed transformers, are temperature rises above the ambient air temperature, and for water cooling are temperature rises above the inlet water temperature. The standard reference ambient temperature for the purpose of these requirements is 85° F. (29·5° C.) in the case of sea water cooling, while for air it is 113° F. (45° C.).

TEMPERATURE RISE LIMITS ON TRANSFORMERS WITH DIFFERENT TYPES OF COOLING.

WINDINGS.—Average temperature-rise as measured by increase in resistance of the winding connected between the terminals.				
Type.	Oil Circulation.	Cooling.	Insulation.	
			Class A.	Class B.
1.	2.	3.	4.	5.
Dry	—	Air Natural Air Blast	90° F. (50° C.)	126° F. (70° C.)
Oil-immersed	Natural thermal head only	Air Natural Air Blast Water	99° F. (55° C.)	—
	Forced Circulation by external pumps	Air Natural	108° F. (60° C.)	—
		Air Blast	108° F. (60° C.)	—
		Water	117° F. (65° C.)	—
OIL.—(For all oil immersed types) temperature-rise (by thermometer)—81° F. (45° C.).				
CORES.—(For all types) the temperature-rise when measured by thermometer on the external surface of the core is not to exceed that permitted for the adjacent windings.				

3. All transformers while in service are to be capable of withstanding short-circuit without injury for the time periods given below, normal line voltage being maintained.

DURATION OF SHORT-CIRCUIT WITH REFERENCE TO IMPEDANCE VOLTAGE.

Impedance Voltage.	Duration of Short-Circuit in seconds.
4%	2
5%	3
6%	4
7% and above	5

Transformers having an impedance less than 4 per cent. are to be capable of withstanding, under service conditions, 25 times normal full-load current for two seconds.

4. The voltage ratio is to be within 0·5 per cent. of the declared ratio, or a percentage equal to 1 tenth of the percentage impedance voltage at rated load, whichever is the smaller.

5. An applied high voltage test is to be carried out on every transformer at the Manufacturer's Works, preferably with the transformer hot immediately after the temperature test, if any. The test is to be applied between the winding under test and the remaining windings, frame and tank of the transformer all connected to earth.

The test is to be made with alternating-current at any convenient frequency between 25 c/s and twice the rated frequency of the transformer, but preferably at the rated frequency. The full test voltage is to be maintained for one minute.

APPLIED VOLTAGE TEST.

NOTE.—In the Table "E" denotes the service voltage in kV (between lines).

System and No. of Phases.	Test Voltage in kV.		
	System with Neutral or Centre Point Insulated or Earthed through current-limiting device.	System with Neutral or Centre Point earthed direct.	
	Transformer not earthed or earthed through current-limiting device.	Transformer	
		Not earthed	Earthed direct.
Single-phase	1+2E	1+1·73E	1+1·4E
Two-phase	1+3·46E	1+3·46E	1+2·8E
Three-phase	1+2E	1+2E	1+1·6E

Single-phase transformers for use in a polyphase group are to be tested in accordance with the requirements for the transformers as connected together on the system.

6. An induced high voltage test is to be carried out on every transformer at the Manufacturer's Works, in which a voltage is applied across the terminals of one winding of the transformer sufficiently in excess of its rated voltage to induce voltages of the specified test magnitudes in all windings. This test is made by utilising an external source of voltage usually having the same number of phases as the transformer under test and provides a graduated test of the insulation between separate windings and the adjacent parts, and also a test of the inter-turn and inter-coil insulation.

The test is to be carried out as follows:—

To the terminals of either the higher- or lower-voltage windings is to be applied an A.C. voltage of as nearly as possible sine-wave form and at approximately twice the rated frequency to avoid excessive exciting current during the test. The windings not connected to the exciting source are to be left on open circuit, and steps taken to ensure that excessive voltages do not occur during the test. Any winding may be earthed at any point at the discretion of the Manufacturer during this test.

The test voltage between the line terminals or between one line terminal and neutral is to be twice the normal voltage between these terminals under working conditions. The test is to be commenced at about one-third of the test voltage and is to be increased to its full value as rapidly as is consistent with its magnitude being indicated by the measuring instrument. The standard duration of the test is 60 seconds for any test frequency up to and including twice the rated frequency. When the test frequency exceeds twice the rated frequency the duration of the test in seconds is to be equal to:—

$$60 \times \frac{2 \times \text{rated frequency}}{\text{test frequency}}$$

but in no case is the duration of the test to be less than 15 seconds. At the end of the test, the voltage is to be diminished rapidly to one-third of the test voltage before switching off.

In the case of three-phase transformers in which the induced voltage test is applied as a single-phase voltage and the resultant voltage therefrom between adjacent line terminals does not reach twice the rated voltage, a supplementary test with the same or other circuit connections is to be made in order to obtain the specified voltage between line terminals.

7. In the case of repairs affecting the windings of a transformer which has been in service, the transformer is not to be put back into service after such repair until it has passed high voltage tests using test voltages equal to 75 per cent. of those prescribed above.

71, FENCHURCH STREET, LONDON, E.C.3.

20th May, 1948.

REFRIGERATING MACHINERY
AND
APPLIANCES OF SHIPS.

INDEX

REFRIGERATING MACHINERY AND APPLIANCES OF SHIPS.

	Section.	Clause.	Page.
Access Plugs	3	4	455
Brine cooling systems	3	19	457
Bulkheads	3	1	455
Cargo battens	3	7	456
Classification and certificates ...	1	1	453
Cooling tests	2	12	455
Fans	2	11	455
Fireproof insulation	3	5	455
Hydraulic and other tests	2	6	454
Information to be submitted	1	2	453
Insulation and fittings	3	—	455
,, ,, protection of ...	3	3	455
Location of machinery	2	5	454
Motive power	2	4	454
Oil engines	2	9	455
Oil separator	2	8	455
Plans, submission of	1	2(*d*)	453
Power of machinery	2	3	454
Pressure vessels	2	10	455

	Section.	Clause.	Page
Safety valves	2	7	455
Spare gear	4	—	456
Special cases	1	3	453
Survey, complete	6	1(*b*)	457
		5	457
,, installations not built under	5	—	457
,, loading port	6	1(*a*)	457
		3	457
,, modified	6	1(*c*)	457
		4	458
,, of repairs	6	9	459
,, running	6	1(*d*)	457
		6	458
Surveys periodical, ...	6	—	457
,, record of	6	2	457
,, special	6	1(*e*)	457
		7	459
		8	459
Thermometer tubes	3	8	456
Ventilation of brine cooling and return tanks	3	9(*b*)	456
,, of open brine tank compartments	3	9(*c*)	456
Watertight bulkhead fittings ...	3	6	456

RULES FOR REFRIGERATING MACHINERY AND APPLIANCES OF SHIPS.

Section 1.

GENERAL.

1. On the application of Owners of ships intended to carry refrigerated cargoes, the Committee will authorise their Surveyors to survey the refrigerating machinery and appliances during construction and installation, and in those cases where the requirements of the Rules detailed below are complied with and a satisfactory report is received from the Surveyors, certificates of classification will be issued and the notation of ✠Lloyd'sRMC (*in red*) (*i.e.*, Lloyd's Refrigerating Machinery Certificate) will be made against the ship's name in the Society's Register Book.

The Committee will also be prepared to authorise their Surveyors to survey existing installations for a notation of Lloyd'sRMC (*in red*) provided the requirements of the Rules for such installations be satisfactorily carried out.

The number of refrigerating units, number of compressors, the system of refrigeration, the name of the maker and date of the construction of the machines, the method employed for cooling the chambers and the nature of the insulation, and the refrigeration or ice melting capacity in tons per 24 hours, and the number and total capacity of the insulated cargo chambers in cubic feet, will be recorded in the special list of Ships fitted with Refrigerated Appliances in the Register Book.

2. **Information to be Submitted.**—Where refrigerating machinery and appliances are to be built under Special Survey, the following information is to be forwarded for consideration before the construction of the installation is commenced: —

(*a*) Standard data sheet giving calculations of heat loading and machine output. (Copies of this data sheet may be obtained from the Society's local offices.)

(*b*) Detailed specification of the refrigerating machinery.

(*c*) Detailed specification of the insulation.

(*d*) The following plans and any other plans which may be specially requested :—

General arrangement of insulated chambers in elevation and plan.

Details of insulation showing thicknesses and methods of attachment of insulation and linings ; method of attachment of meat rails, brine or direct expansion grids ; details of insulated doors, hatch, bilge and manhole plugs.

Arrangement of air ducts.

Arrangement of chamber thermometers.

Arrangement of fan motors.

Arrangement of fans and coolers.

Brine circuit diagram.

General arrangement of refrigerating machinery.

Refrigerant gas and liquid circuit diagram.

Sectional arrangement of compressor.

Compressor crank shaft.

Compressor crank case where exposed to the pressure of the refrigerant gas.

Condenser.

Evaporator.

Details of pressure vessels.

3. **Special Cases.**—The Committee will be prepared to give consideration to cases of ships engaged on voyages of short duration or to other special circumstances.

Section 2.

REFRIGERATING MACHINERY.

1. **Definition of a Unit.**—A refrigerating unit comprises a prime mover, one or more compressors, one condenser, one evaporator or cooler, and fittings necessary to form an independent gas and liquid system.

If the prime mover is a steam engine and each cylinder drives a corresponding compressor, or if there is more than one motor similarly arranged and each compressor is connected to its own condenser and evaporator or cooler (not necessarily in separate casings), these machines are to be

described as two or more units, as the case may be, provided each unit can be used either in combination or separately.

If a machine has more than one compressor, but is driven by a single prime mover and has only one condenser and one evaporator or cooler, it is to be described as one unit with one or more compressors.

In the case of compound compressors the high and low pressure cylinders are to be considered as a single compressor.

2. **Ice melting capacity.**—The refrigeration or ice-melting capacity of the machines in tons per 24 hours should be calculated at the rate of 318,080 B.T.U. per English ton (*i.e.*, 2,240 pounds) with temperature of evaporation = 5° F. (−15° C.), and temperature of liquid refrigerant in the condenser = 86° F. (30° C.).

3. **Power of Machinery.**—(*a*) The refrigerating machinery is to be of approved construction and power.

(*b*) Not less than two complete units of refrigerating machinery are to be fitted.

(*c*) Where two units are fitted their working parts are to be interchangeable, and the power of each unit is to be not less than that necessary to maintain the temperature for which the plant is intended, when the cargo is stowed at a proper temperature and the plant is working 24 hours a day in the tropics.

(*d*) When more than two units are fitted, the power provided is to be not less than that necessary to maintain the temperatures for which the plant is intended, when the cargo is stowed at the proper temperature and the plant is working 24 hours a day in the tropics with any one unit out of action.

(*e*) In addition to the brine pumps and the gas condenser water circulating pump required for the maximum duty, a standby brine pump and water circulating pump are to be fitted, ready for use. The additional water circulating pump may be one of the pumps used for other purposes provided it is of adequate capacity and its use on the gas condenser does not interfere with other essential services. The circulating water is to be taken from two sea connections one of which may be the water ballast inlet.

(*f*) In any case where the total power is not available for all the insulated cargo chambers, the machinery serving each group of chambers is to comply with the foregoing requirements and the requirements for spare gear.

(*g*) Where the machinery is steam driven, the exhaust steam is to be led to the main and auxiliary condensers.

4. **Motive Power.**—The motive power is to be taken from at least two sources, each capable of the maximum duty without interference with other essential services.

5. **Location of Machinery.**—Where ammonia or methyl chloride refrigerant is used, the refrigerating machinery is to be placed in an efficiently ventilated compartment isolated from the propelling machinery spaces.

6. **Hydraulic and other Tests.**—In the case of new refrigerating machinery and appliances, the tests required are :—

(*a*) CO_2 compressors, intermediate liquid coolers, separators, condenser and evaporator coils, headers and connections, condensers and evaporators of the multitubular and double pipe types, to be tested by hydraulic pressure to 3,000 lb. per square inch, and afterwards by air pressure to 1,500 lb. per square inch whilst submerged in water at a temperature of 90° F.

(*b*) NH_3 compressors and cast iron or steel connections to be tested by hydraulic pressure to 600 lb. per square inch, and afterwards by air pressure to 300 lb. per square inch whilst submerged in water at a temperature of 90° F.

NH_3 crank cases which are subjected to gas pressure to be tested by hydraulic pressure to 300 lb. per square inch, and afterwards by air pressure to 150 lb. per square inch whilst submerged in water at a temperature of 90° F.

(*c*) NH_3 condenser, evaporator and air cooler coils to be tested by hydraulic pressure to 1,500 lb. per square inch, and afterwards by air pressure to 500 lb. per square inch whilst submerged in water at 90° F.

NH_3 condensers or evaporators of the multitubular, double pipe or shell and tube types and welded pressure vessels to be tested by hydraulic pressure to 500 lb. per square inch, and afterwards by air pressure to 250 lb. per square inch whilst submerged in water at 90° F.

Where it is inconvenient to test the larger sizes by submersion in water, the shells may be charged with air and NH_3 and tested by means of litmus paper or sulphur sticks.

(*d*) NH_3 condenser, evaporator and air cooler coils to be tested after erection in place by air pressure to 200 lb. per square inch.

(*e*) Brine piping after erection in place to be tested by hydraulic pressure to double the working pressure at the brine circulating pumps, but in any case not less than 50 lb. per square inch.

Sections of brine leads (service pipes) which have to be insulated before the circuits are complete may be tested by air pressure to 90 lb. per square inch in lieu of the hydraulic test.

(*f*) Gas evaporator casings of cast iron and gas condenser casings, whether of cast iron or steel, to be tested by hydraulic pressure to 15 lb. per square inch, or to double the working pressure, whichever is the greater.

(*g*) Gas evaporator, wrought iron and steel casings, to be tested by hydraulic pressure to 30 lb., if gravitation type, or to 50 lb. per square inch if pressure type, or to double the working pressure, whichever is the greater.

(*h*) CCl_2F_2 (Freon 12) and CH_3Cl (Methyl Chloride), all parts exposed to the pressure of the refrigerant gas, with the exception of the compressor crank case, to be tested by oil pressure to 350 lb. per square inch, and afterwards by air or gas pressure to 200 lb. per square inch whilst submerged in water at a temperature of 90° F.

CCl_2F_2 and CH_3Cl crank cases which are subjected to gas pressure to be tested by water or oil pressure to 200 lb. per square inch, and afterwards by air or gas pressure to 150 lb. per square inch whilst submerged in water at a temperature of 90° F.

(*i*) Important steel castings and steel forgings are to comply with the requirements of **Sections 9** and **10**, respectively, of the **Rules for the Quality and Testing of Materials.**

Where refrigerant pipes are made of steel, the material is to comply with the requirements of **Section 16, clauses 1** and **2**, of the **Rules for the Quality and Testing of Materials.**

7. **Safety Valves.**—(*a*) Suitable spring-loaded safety valves are to be provided on condenser casings and evaporator casings of pressure type.

(*b*) A relief valve or safety disc is to be fitted on or near each compressor on the gas delivery side.

8. **Oil Separator.**—A suitable oil separator with drain to be fitted to the gas line near the compressor.

9. **Oil Engines.**—Where refrigerating machinery is driven direct by oil engines, the sizes of the crank shafts and particulars of the engines and of the proposed spare gear in connection therewith are to be submitted for consideration.

10. **Pressure Vessels.**—Welded pressure vessels exposed to the pressure of the refrigerant are to be constructed in accordance with the **Rules for Welded Pressure Vessels,** with the exception that hydraulic and air tests are to be carried out in accordance with **clause 5** above.

11. **Fans.**—Where air circulating fans for refrigerated chambers are electrically driven, the fan motors are to be inspected by the Surveyors during manufacture and testing irrespective of the horse-power rating of the motors.

The access arrangements to the fans are to be such that the fans and motors may be readily removed for repair or renewal when the chambers are loaded with refrigerated cargo.

12. **Cooling Tests.**—Upon completion of the installation under special survey the refrigerating machinery is to be tested under working conditions and the insulated chambers are to be cooled down simultaneously to about 10° F. where they are intended for carrying frozen and chilled meat cargoes, and to about 20° F. where they are intended for carrying fruit and similar produce which require only moderate temperatures. The rise of temperature in the refrigerated chambers is to be noted upon the expiration of about 12 hours time after the machinery and cooling appliances have been shut off.

Section 3.

INSULATION AND FITTINGS.

1. **Bulkheads.**—The transverse or longitudinal terminal bulkheads separating insulated from non-insulated compartments are to be of steel construction and hose-tested for tightness.

Where dis-similar cargoes may be carried in the separate compartments, the divisional bulkheads between the insulated compartments are to be of steel construction and hose-tested for tightness.

2. **Insulation.**—The insulation is to be sound and in good order and of efficient construction. The details of construction showing the amount and nature of the insulating material employed in the various parts are to be reported to the Committee.

3. **Protection of Insulation.**—The insulation of the lower hold chamber floor and the tunnel top in way of the hatchways and about two feet beyond are to be protected with hardwood sheathing about two inches thick or similar protection.

4. **Access Plugs.**—Insulated removable portions are to be arranged in the insulation, where required, to provide easy access to the bilges and bilge suction roses. Similar provision to be made for access to the tank air and sounding pipes.

5. **Fireproof Insulation.**—The insulation in way of coal bunkers and of any surfaces exposed to excessive heat, is to be silicate cotton, or other approved fireproof material,

the wood grounds are to be fireproofed and asbestos strips are to be fitted between the wood grounds and the steel work to which they are attached.

Brine leads in bunkers may be packed with granulated cork, but there is to be a thick outer covering of silicate cotton and the whole protected by steel plates.

6. **Watertight Bulkhead Fittings.**—Where cooling pipes pass through watertight bulkheads, or deck plating, the fittings and packing of the stuffing boxes are to be both fireproof and watertight.

7. **Cargo Battens.**—(*a*) Cargo battens are to be provided for the floor or deck and the walls of the chambers previous to loading refrigerated cargoes.

(*b*) Those for the walls of the chambers are to be fastened and should be at least 2 inches × 2 inches, one batten being placed over each frame or ground, the others being intermediately arranged, to suit the class of cargo.

(*c*) The cargo battens for the floors or decks of the chambers are to be fitted to suit the class of cargo.

(*d*) The tunnel top insulation is to be fitted with 3 inch × 3 inch battens.

8. **Thermometer Tubes.**—(*a*) The number and position of the thermometer tubes in the insulated chambers should be submitted for consideration.

(*b*) Thermometer tubes, their flanges and covers are to be insulated from the deck plating and on weather decks they are to be so arranged that water will not run down when taking the temperatures.

(*c*) The inside diameter of thermometer tubes is to be not less than 2 inches and the tubes are to be out of contact with cold decks.

(*d*) Where the thermometer tubes and cooling pipes pass through compartments or chambers other than their respective insulated chambers they are to be efficiently insulated.

9. **Brine Cooling Systems.**—(*a*) Where the brine system of refrigeration is employed the brine circulating pipes and tanks should not be galvanized on the inside.

(*b*) In cases where internally galvanized tanks or cooling pipes are fitted, the brine cooling and return tanks, if closed, are each to be provided with a ventilating pipe or pipes led to the open air in a situation where no danger will be incurred from the issuing gas, and each ventilating pipe must be fitted with a wire gauze diaphragm which can be easily removed for renewal.

(*c*) Where the tanks are not closed, the compartments in which they are situated must be efficiently ventilated.

(*d*) The brine pipes in each refrigerated chamber are to be arranged in not less than two sections, but particulars of the number and arrangement of sections are to be submitted for consideration. Valves or cocks are to be fitted so that any section can be shut off when necessary.

(*e*) The thickness of the brine pipes at the bottom of the screw threads should not be less than $\frac{3}{32}$ of an inch.

For sounding pipes, protection of pipes, draining arrangements and insulation of oil storage tank tops and bulkheads *see* **Rules for Pumping and Piping.**

Section 4.

SPARE GEAR.

1. The following spare gear will be required in all cases:—

Lengths and bends of piping of each size used, together with flanges, couplings and screwing apparatus.
Sundry cocks, valves, flanges and fittings.
Assorted bolts, studs and nuts.
A quantity of packings and joint rings.
1 complete set of crank shaft coupling bolts.
1 complete set of motor coupling bolts and washers.
1 compressor piston and rod complete for each size used.
1 set of compressor suction and delivery valves with rings and boxes for each size used.
1 complete set of packing for the compressor piston rod for each size used.
1 gas regulator valve complete.
1 set of valves for water circulating, air and brine pumps for each size used.
In cases where approval is given to alternative arrangements under **Section 2, clause 3,** additional spare gear may be required according to the circumstances of the case.

2. Where steam driven air circulating fans are fitted, the following spare gear will be required:—

For each size used:—

1 crank shaft.
1 steam piston and rod complete.
1 steam cylinder cover.
1 set of connecting rod top and bottom end, and bearing bushes, and bolts complete.

3. Where the refrigerating machinery or its auxiliaries are electrically driven, the following spare gear will be required :—

(*a*) For the generators, motors, control gear and switchboard, a set of spare gear in accordance with **Section 24** of the **Rules for Electrical Equipment.**

(*b*) For electrically driven air circulating fans the following spare gear will be required :—

1 complete fan and motor of each size used.

4. Where the refrigerating machinery is driven direct by oil engines, the proposed spare gear for the engines is to be submitted for consideration.

Section 5.

INSTALLATIONS NOT BUILT UNDER SURVEY.

(*a*) Where a character is required for Refrigerating Installations not surveyed while under construction, application must be made to the Committee in writing. Specifications and drawings showing particulars of machinery and insulation are to be furnished, together with general particulars of the steel used for important steel castings, forgings and refrigerant pressure piping.

(*b*) A special examination is to be made at least to the extent required for Subsequent Special Surveys (**Section 6, clauses 4, 5, 7** and 8).

(*c*) The thicknesses and material of the insulation, particulars of the cooling equipment provided for the chambers, and particulars of the compressors, evaporators and condensers are to be verified.

(*d*) Pressure relief devices, cargo battening arrangements, thermometer tubes and draining arrangements are to be made to conform to the requirements of the Rules.

(*e*) The refrigerating machinery log is to be examined in order to ascertain that the machinery power provided is adequate, and if considered necessary, a cooling test on the installation is to be carried out.

(*f*) Periodical surveys are subsequently to be held as in the case of vessels built under survey.

Section 6.

PERIODICAL SURVEYS.

1. **Incidence of Surveys.**—To entitle ships to retain the character assigned to the Refrigerating Machinery installation, they are to be subjected to the following periodical surveys :—

(*a*) A **Loading Port Survey,** as detailed in **clause 3,** is to be held at the loading port every voyage in the case of ships engaged on voyages of more than two months' duration, but where the voyages are of shorter duration, this survey need only be held at intervals of two months, provided the cargoes carried be of such a nature as not to damage the insulation or appliances in the insulated chambers nor to affect the refrigerated cargoes by taint or mould.

(*b*) A **Complete Survey** as detailed in **clause 5** is to be held every twelve months.

(*c*) A **Modified Survey** as detailed in **clause 4** is to be held about six months after the Complete Survey.

(*d*) A **Running Survey** as detailed in **clause 6** may be held, if desired by the Owners, at intervals of not longer than six months in lieu of the Modified and Complete Surveys.

(*e*) A **Special Survey** as detailed in **clauses 7** and **8** is to be held upon the occasions of the ship undergoing the Special Periodical Surveys prescribed in the **Rules for Steel Ships** in the case of ships classed with this Society, and at intervals of four years in the case of ships not so classed.

2. **Record of Surveys.**—(*a*) The date following the record "Lloyd'sRMC" (*in red*) indicates the date of the last Complete Survey of the refrigerating machinery and appliances, thus :—"Lloyd'sRMC3,49" (*in red*).

(*b*) The date under the record "Lloyd'sRMC" (*in red*) indicates the date of the last Modified Survey of the refrigerating machinery and appliances, thus :—"Lloyd'sRMC3,49
9,49" (*in red*).

(*c*) Where Running Surveys are held in lieu of the Modified and Complete Surveys, this will be indicated by the record "Lloyd'sRMC (RS)" (with date) (*in red*), the date being that of the last examination in accordance with **clause 6.**

(*d*) The date of the last Special Survey in accordance with **clauses 7** and **8** will be recorded under the name of the ship, thus :—"SRMC3,49" (*in red*).

(*e*) Where, in any case, only part of the requisite examination is held, the certificate will be endorsed with the statement of what is required to complete the survey.

3. **Loading Port Survey.**—(*a*) The chambers are to be examined to ascertain that they are clean and free from odour, that the brine pipes are free from leakage, that the cargo battens are in good order and that no damage has been sustained to the insulation prior to the loading of the refrigerated cargo.

(*b*) The chambers should be examined under frosted conditions and any indications of deficient insulation not considered to warrant immediate attention should be noted and specially reported.

(*c*) The Surveyor is to satisfy himself that all scuppers and bilge suctions draining insulated spaces are in good working order.

(*d*) The refrigerated machinery is to be tested under working conditions, the temperatures in the chambers being noted.

(*e*) If the ship loads at more than one port, one survey only at a loading port will be required, provided it includes the examination of all the chambers, and general cargo is not subsequently carried in the refrigerated chambers prior to loading refrigerated cargo.

(*f*) If there is not a Surveyor to the Society available at the loading ports, or if there is not one obtainable from a port within a reasonable distance, the Committee will accept the report of a survey held at the loading port by a Surveyor appointed by Lloyd's agent; or (in any case where there is no Lloyd's agent) the report of a survey held by a reliable Surveyor, if available; or (if no such Surveyor is available) a report signed by two competent Engineers of the ship.

4. Modified Survey.—(*a*) The machinery is to be examined under working conditions on the ship's arrival at the port of discharge, before the refrigerated cargo is fully discharged.

(*b*) The refrigerating machinery log is to be examined in order to ascertain that the machinery has been operating satisfactorily during the voyage with refrigerated cargo.

(*c*) The compressor cylinders and valves are to be examined; the piston and piston rod need not be withdrawn for examination unless considered necessary by the Surveyors.

(*d*) Where the refrigerating machinery or its auxiliaries are electrically driven, a general examination of all the generators, motors and their control gear, and cables, is to be made and the insulation resistance measured. The insulation resistance is to be not less than 100,000 ohms, and for the purpose of this test each item may be taken separately. Where an Owner employs a competent and reliable staff or electrical contractor, Surveyors may consult their records and at their discretion accept megger tests carried out by them.

(*e*) The spare gear is to be examined.

(*f*) The gas and liquid pipes, separators, receivers, condenser and evaporator coil terminals are to be examined externally as far as practicable.

(*g*) The brine pipes are to be examined.

(*h*) Direct expansion pipes are to be examined under full working conditions.

(*i*) The insulation throughout the cargo chambers is to be carefully examined. Where silicate cotton, granulated cork or similar media are employed for insulating purposes, the insulation is to be examined for fullness and dryness by boring where necessary. The test holes are to be efficiently closed. Special attention is to be paid to the insulation under trunks and hatches where dampness may accumulate, to the sides under stringers and under decks, and to the tunnel tops. All bilge and manhole plug hatches are to be removed, the bilges cleared and the suction pipes, suction roses and sounding pipes are to be examined. Hatches, air trunkways and thermometer tubes, with their connections and fastenings, are to be examined.

(*j*) The Surveyor is to satisfy himself that all scuppers draining insulated spaces are in good working order.

5. Complete Survey.—(*a*) All the requirements of clause 4 (Modified Survey) are to be complied with.

(*b*) The compressor crank shafts, connecting rods, bearings, pistons and piston rods are to be examined.

(*c*) Where the refrigerating machinery is driven by steam or internal combustion engines, the cylinders, pistons, valves, crank shafts, connecting rods and bearings are to be examined.

(*d*) Where the refrigerating machinery is electrically driven, one of the engines or turbines driving the generators is to be opened up and examined completely in regular rotation.

(*e*) The working parts of the water and brine circulating pumps are to be examined.

(*f*) Where other auxiliary machinery is fitted, the working parts are to be examined.

(*g*) The brine pipes are to be tested to 1½ times the working pressure, or 40 lb. per square inch, whichever is the greater.

6. Running Survey.—(*a*) All the requirements of clause 4 (Modified Survey), except paragraph (*c*), are to be complied with.

(*b*) The compressor cylinders, valves, crank shaft, connecting rods, bearings, pistons and piston rods of

one or more machines are to be examined at each survey in regular rotation, so that all machines are examined within a period of twelve months.

(*c*) Where the refrigerating machinery is driven by steam or internal combustion engines, the cylinders, pistons, valves, crank shaft, connecting rods and bearings of one or more engines, are to be examined at each survey in regular rotation, so that all the driving engines are examined within a period of twelve months.

(*d*) Where the refrigerating machinery is electrically driven, one of the engines or turbines driving the generators is to be opened up and examined completely at intervals of not more than twelve months, in regular rotation.

(*e*) The working parts of one or more brine pumps and one or more circulating pumps are to be examined at each survey in regular rotation, so that all the pumps are examined within a period of twelve months.

(*f*) Where other auxiliary machinery is fitted, the working parts are to be examined.

(*g*) The brine pipes are to be tested to 1½ times the working pressure, or 40 lb. per square inch, whichever is the greater, at intervals of not more than twelve months.

(*h*) A Survey Book is to be kept on board the ship to show the date of examination of the various parts, and is to be signed by the Surveyor on the occasion of each survey.

7. **First Special Survey.**—(*a*) All the requirements of clause 5 (Complete Survey) are to be complied with except where the surveys are being held in accordance with clause 1 (*d*), when the requirements of clause 6 (Running Survey) are to be complied with.

(*b*) Where the refrigerating machinery or the generators supplying the refrigerating machinery are driven by steam engines, the air and feed pumps, steam pipes and steam condenser are to be examined, and, if necessary, the steam condenser is to be tested.

(*c*) Where the refrigerating machinery is driven by internal combustion engines, the cylinders, pistons, valves, crank shafts, piston and connecting rods and bearings of the air compressors are to be examined. The air receivers and air pressure pipes are to be cleaned internally. The air receivers are to be examined internally and in cases where the construction of the receivers is such that a proper internal examination cannot be made, they are to be tested by hydraulic pressure to 1½ times the working pressure.

(*d*) Sufficient insulation is to be stripped from groups of brine pipe leads, or brine mains, in bunkers or near boilers or where buried in hold insulation to permit of the condition of the pipes being ascertained.

(*e*) Sufficient air trunking or baffle boarding is to be stripped to permit of the condition of the insulation and lining being ascertained.

(*f*) Sufficient tank top insulation is to be stripped to permit of the condition of the grounds and inner insulation lining being ascertained.

(*g*) Sea injection valves are to be opened up and examined.

(*h*) All thermometers used for measuring chamber and air suction and delivery temperatures are to be checked.

8. **Subsequent Special Surveys.**—(*a*) All the requirements of clause 7 (First Special Survey) are to be complied with.

(*b*) The coils of gas condensers and evaporators of the shell and coil type are to be drawn for examination and tested to a pressure of 300 lb. per square inch for Methyl Chloride or Freon systems, 1,000 lb. per square inch for Ammonia systems and 2,500 lb. per square inch for Carbon Dioxide systems.

(*c*) Gas condensers and evaporators of the shell and tube type are to have the water or brine end covers removed, and are to be tested to a pressure of 300 lb. per square inch for Methyl Chloride or Freon systems, and 400 lb. per square inch for Ammonia systems.

(*d*) Direct expansion grids or batteries are to be tested in place to a pressure of 100 lb. per square inch for Methyl Chloride or Freon systems, and 150 lb. per square inch for Ammonia systems.

9. **Survey of Repairs.**—Where any essential repairs or renewals are effected to the refrigerating machinery or insulation, these must be carried out under the inspection, and to the satisfaction, of the Society's Surveyors. Repairs and renewals effected at ports where there is no Surveyor to this Society must be surveyed by one of the Society's Surveyors at the earliest opportunity.

71, Fenchurch Street, London, E.C.3.
15th December, 1949.

QUALITY AND TESTING OF MATERIALS.

INDEX

QUALITY AND TESTING OF MATERIALS.

A

	Section.	Clause.	Page.
Additional tests (*see* Rejection).			
Alternative proposals	1	12	466
Anchors, Admiralty pattern	13	2(*b*)	475
„ cast steel	13	—	475
„ heat treatment of	13	5	475
„ process of manufacture and tests for	12	1(*a*)	474
Angle Bars, bend and tensile tests (ship steel)	3	2(*b*)	467
„ „ (boiler steel)	5	3(*b*)	468

B

Bend Test Pieces, number of, for ship steel	3	1	467
„ „ „ boiler steel	3	2	467
„ „ „ steel castings	9	4	471
„ dimensions of, ingot steel forgings	10	7	473
Bend Tests, ship and boiler steel ...	3	—	467
„ steel castings	9	8	471
„ ingot steel forgings ...	10	7–9	473
„ cast steel anchors	13	4	475
Bessemer Steel, prohibited for anchor forgings	12	1	474
Boiler Steel, tests for (*see* also **Tests**) ...	5	—	468
Branding, after testing, of plates and bars	1	6	465
„ „ „ ingot steel forgings	10	13	473
„ „ „ steel castings ...	9	14	472
Breaking Tests, chain cables and shackles	14	—	476
„ steel wire rope	15	—	477
„ „ towlines, hawsers and warps	15	—	477
„ „ standing rigging	15	—	477
Bronze Propellers and Bronze Propeller Blades, testing of	11	—	474
Bulb Angles, tensile breaking strength of	4	2(*b*)	467

C

Cast Iron, steel castings in lieu of ...	9	3(*c*)	471
Steel Anchors	13	—	475
Castings of complex design	9	11	471
„ steel, heat treatment of ...	9	2	471
„ „ process of manufacture ...	9	1	471
„ „ testing, inspection and branding of	9	—	471
Certificates, anchors	12	2	474
„ chains, cables	14	1(*a*)	476
„ hawsers and towlines ...	15	2	477
„ Steel Makers'	1	8, 10	465,466
Chain Cables, proving establishments, list of	—	—	503
„ tests for stud link (Table)	14	—	476
Chains, unstudded short-link, test for (Table)...	14	—	476
Channels, tensile breaking strength of ...	4	2(*b*)	467
Combustion Chambers, special iron for screw stays for	8	—	470
Connecting Rods, forgings	10	1(*b*)	472
Crank Shafts forgings	10	1(*b*)	472
Crossheads, percussive tests	9	10	471

D

Defacing of Rejected Material	1	7	465
Drilling Tests, steel castings	9	13	472
Drums, seamless steel for Boilers ...	10A	—	473
Ductility of Test Pieces, cast steel anchors	13	4	475
Dump Test, rivet bars	6	4	469

E

Elongation of boiler stay bar test pieces	5	3(*c*)	468
„ „ steel angle and tee bars	5	3(*b*)	468
„ „ steel test pieces ...	5	3(*a*)	468
„ forging test pieces ...	10	6	472
„ ship steel angle test pieces	4	2(*b*)	467
„ „ plate test pieces	4	2(*a*)	467
„ steel casting test pieces ...	9	6	471
„ test pieces of special iron screw stays for c.c. ...	8	2	470

	Section.	Clause.	Page.
F			
Facilities for Inspection	1	9	465
Forgings, ingot steel, heat treatment of	10	2	472
„ process of manufacture ...	10	1	472
„ soft ingot steel in place of wrought iron	10	6(*b*)	472
„ testing, inspection and branding of	10	—	472
H			
Hammering Tests, steel castings ...	9	12	472
„ cast steel anchors ...	13	3	475
Hawsers, breaking tests for (Table) ...	15	—	477
Heat Treatment of anchors	13	5	475
„ „ castings	9	2	471
„ „ forgings	10	2	472
I			
Ingot Steel for anchors	12	1	474
„ „ forgings...	10	—	472
„ soft for forgings	10	6(*b*)	472
Iron special for screw stays for combustion chambers	8	—	470
„ forged wrought, for anchors ...	12	1	474
M			
Marking of material by maker for facility in tracing	1	6–10	465
O			
Occasional attendance at steel works ...	4	3	467
P			
Percussive Tests, steel castings... ...	9	10	471
„ cast steel anchors ...	13	2	475
„ castings of complex design	9	11	471
„ crossheads	9	10	471
„ rudders	9	10	471
„ steering quadrants ...	9	10	471
„ stern frames	9	10	471
„ tillers	9	10	471
Piston Rods, forgings of...	10	1(*b*)	472
Plates (ship steel)	4	1	467
„ tensile tests ...	4	2(*a*)	467
„ „ „ number of	4	1	467
„ (boiler steel)	5	1	468
„ „ tensile tests ...	5	3	468
„ „ „ number of	5	2	468
Propeller Posts, soft ingot steel for ...	10	6(*b*)	472
Q			
Quadrants, rudder and steering, percussive test	9	10	471
R			
Rejected Material, defacing of	1	7	465
Rejection, additional test before, of steel castings	9	9	471
„ additional test before, of steel plates, bars and angles ...	1	5	465
„ additional test before, of ingot steel forgings	10	9	473
Rivet Bars, bend tests not required ...	3	3(*a*)	467
„ dump test	6	4 / 2(*d*)	469
„ nicked bend test	6	5	469
„ number of tensile tests of steel for	6	2	469
„ tensile breaking strength of	6	3	469
Rivets, manufactured, tests for	6	6	469
Rudder Forgings, heads and main pieces	10	1(*b*)	472
Rudders, percussive tests...	9	10	471
„ soft ingot steel for	10	6(*b*)	472
S			
Screw Stays for combustion chambers, special iron for	8	—	470
Seamless Steel Drums for boilers ...	10A	—	473
Shafts, forgings of	10	1(*b*)	472
Shearing, removal of rough edge caused by	3	3(*b*)	467
Ship Steel, testing of (*see* also **Tests**) ...	4	—	467
Short Link chain cables	14	1(*b*)	477
Soft Open Hearth Ingot Steel in place of wrought iron for forgings ...	10	6(*b*)	472
Special Requirements. Ship Steel and Boiler Materials	1	13	466
Standard Test Pieces (with sketches) (*see* also **Test Pieces**)	2	—	466
„ tensile test, plates	2	2	466
„ tensile test, round bars	2	3	466
„ straightening of test pieces ...	2	4	467
Statutory Tests of Anchors	12	—	474
„ „ chain cables and shackles	14	—	476
Stay Bars, testing of	3 / 5	2(*c*) / 3(*c*)	467 / 468
Steel, freedom from defects	1	3	465
„ not produced where rolled ...	1	10	466
„ of other tenacity than provided for by Rules...	1	12	466
„ process of manufacture	1	2	465
„ special quality for boilers... ...	5	3(*d*)	468
„ „ „ „ shipbuilding ...	7	—	469

	Section.	Clause.	Page.
Steel Manufacturers, list of	—	—	486
Steel Works, occasional attendance at ...	4	3	467
Stern Frames, percussive tests	9	10	471
Stern Posts, soft ingot steel for	10	6(*b*)	472
Strength, tensile breaking, material for boilers and welded pressure vessels	5	3	468
„ „ „ forgings... ...	10	6	472
„ „ „ ship material ...	4	2	467
„ „ „ steel castings ...	9	6	471

T

Tee Bars, tensile breaking strength of	5	3(*b*)	468
Tensile Tests (*see* **Tests**).			
Test Pieces, annealing of	2	1	466
	3	3(*b*)	467
	7	4	470
„ bend, for castings	9	8	471
„ „ forgings	10	8	473
„ „ ship and boiler steel	3	3, 4	467
„ selection of	3	2	467
„ ductility of, cast steel anchors	13	4	475
„ for cast steel anchors ...	13	4	475
„ „ plates	2	2	466
„ „ round bars	2	3	466
„ **Standard**	2	—	466
„ straightening of	2	4	467
„ tensile, for castings... ...	9	3	471
„ „ forgings ...	10	3	472
„ „ rivet bars ...	6	3	469
Tests, Additional, before rejection ...	1	5	465
	9	9	471
	9	10	471
„ „ if considered necessary	1	11	466
„ **Bend,** description of	3	4	467
„ „ for castings	9	8	471
„ „ „ cast steel anchors ...	13	4	475
„ „ „ forgings	10	8	473
„ „ „ special iron for screw stays	8	3	470
„ „ number of, for ship and boiler steel	3	—	467
„ drilling for large castings	9	13	472
„ during occasional attendance ...	4	3	467
„ for anchors	12	—	474
Tests, for chain cables and stream chains	14	—	476
„ „ forged rotors	10	12	473
„ „ manufactured rivets	6	—	469
„ „ steel wire standing rigging ...	15	—	477
„ „ „ rope	15	—	477
„ „ „ towlines, hawsers and warps	15	—	477
„ „ unstudded short-link chains ...	14	1(*b*)	477
„ hammering for castings	9	12	472
„ „ cast steel anchors ...	13	3	475
„ number of, for ingot steel forgings	10	4	472
„ „ „ for steel castings ...	9	4	471
„ percussive, for castings	9	10	471
„ „ „ cast steel anchors ...	13	2	475
„ **Tensile,** for angles and similar sections	4	2(*b*)	467
„ „ angles and tee bars	5	3(*b*)	468
„ „ boiler plates ...	5	3(*a*)	468
„ „ „ steel, number of	5	2	468
„ „ forgings	10	6	472
„ „ rivet bars	6	3	469
„ „ ship plates... ...	4	2	467
„ „ „ steel, number of	4	1	467
„ „ special iron for screw stays	8	2	470
„ „ stay bars	5	3(*c*)	468
„ „ steel castings ...	9	6	471
Tillers, percussive test of	9	10	471
Towlines, steel wire, tests for (Table) ...	15	—	477

U

Unstudded short-link chain	14	1(*b*)	477

W

Warps, steel wire, tests for	15	—	477
Welded Pressure Vessels, tensile tests of steel	5	—	468
Wire rope flexible steel, tests for ...	15	—	477
„ rigging, steel, standing, tests for (Table)	15	—	478

RULES FOR QUALITY AND TESTING OF MATERIALS.

Section 1.

QUALITY AND TESTING OF SHIP STEEL AND BOILER MATERIAL.

Steel Plates, Bars and Angles.

1. **General Regulations.** — The steel used in the construction of ships or boilers intended for ships classed, or proposed for classification, in the Society's Register Book, is to comply with the tests described hereafter.

2. **Process of Manufacture.**—The steel is to be made by the Open Hearth process, Acid or Basic.

3. **Freedom from Defects.**—The finished material is to be free from cracks, surface flaws, and lamination. It is also to have a workmanlike finish, and must not have been hammer-dressed.

4. **Testing and Inspection.**—(*a*) The prescribed tests and inspections are to be made at the place of manufacture prior to despatch ; but, in the event of any of the material proving unsatisfactory in the course of being worked into ships or into boilers, such material shall be rejected, notwithstanding any previous certificate of satisfactory testing, and such further tests of the material from the same charge may be made as the Surveyor may consider desirable.

(*b*) All test pieces are to be selected by the Surveyor and tested in his presence, and he is to satisfy himself that the prescribed conditions are fulfilled.

5. **Additional Tests before Rejection.**—(*a*) Where any of the test pieces first selected by the Surveyor do not fulfil the test requirements, two further tests of the same kind may be made from the same plate or bar, but where either of these fail, the plate or bar from which the test pieces were cut is to be rejected. In all such cases further tests are to be made before any material from the same charge can be accepted.

(*b*) Where a tensile test piece breaks outside the middle half of its gauge length, and the elongation is less than that required by the Rules, the test may, at the Maker's option, be discarded and another test be made of the same plate or bar.

6. **Branding.**—(*a*) Every plate and bar is to be clearly and distinctly marked by the Maker in two places with the Society's brand, thus :— indicating that the material has complied with the Society's tests.

(*b*) Plates or bars bearing this brand are not to be forwarded from the Steel Works until the prescribed tests have been made by the Surveyor, and the mill sheets have been signed by him. All plates and bars are also to be legibly stamped in two places with the Maker's name or trade mark, and the place where made. They are also to be stamped with numbers or identification marks by which they can be traced to the charge from which the material was made.

7. **Defacing of Rejected Material.**—In the event of the material failing, in any case, to withstand the prescribed tests, the Surveyor is to see that the Society's brand stamped on the plates and bars by the Maker has been defaced by punch marks extending beyond the brand in the form of a cross, thus :— denoting that the material has been rejected.

8. **Maker's Certificate.**—Before the mill sheets are signed by the Surveyor, the Maker is required to furnish him with a certificate guaranteeing that the material has been made by the Open Hearth process, and that it has been subjected to, and has withstood satisfactorily, the required tests in the presence of the Surveyor. The following form of certificate will be accepted if printed on each mill sheet with the name of the firm, and initialled by the Test House Manager :—

> "We hereby certify that the material described below has been made by the Open Hearth process, and in accordance with the Rules of Lloyd's Register and is that which has been satisfactorily tested in the presence of the Surveyor."

9. **Facilities for Inspection.**—The Maker is to adopt a system of marking the ingots, billets, slabs, plates, bars, and other material which will enable all finished material to be traced to the original charge, and the Surveyor must be given every facility for tracing all plates and bars to their respective charges, and for witnessing the required tests When the Surveyor is satisfied with the material and with the results of the tests, he is to be furnished with two copies of the advice notes of the material for his signature, one of which is to be forwarded by the Manufacturer to the Shipbuilder or Boiler Maker, and the other is to be forwarded by the Surveyor to the Surveyors at the port where the ship or boiler is to be built.

10. **Steel not produced where Rolled.**—Where steel is not produced in the works at which it is rolled, a certificate is to be supplied to the Surveyor, stating the Open Hearth process by which it was made, the name of the Steel Maker who supplied it, also the numbers of the charges for reference to the books of the Steel Maker. The number of the charge is to be marked on each ingot or billet for the purpose of identification, and the finished plates and bars are also to be legibly stamped in two places with the Maker's name or trade mark, and the place where made. They are also to be stamped with numbers or identification marks by which they can be traced to the charge from which the material was made.

11. **General.**—In addition to the tests described hereafter the material may be subjected to further tests at the discretion of the Surveyors.

12. **Alternative Proposals.**—The Committee will be prepared to consider proposals for the use of steel having properties different from those prescribed in these Rules, provided full particulars of the properties and manufacture of the material are submitted for consideration.

13. **Special Requirements.**—When the main structure of a ship is intended to be wholly or partially welded, the Committee may require parts of primary structural importance over 1 inch in thickness to be of steel, the properties and process of manufacture of which have been specially approved for this purpose.

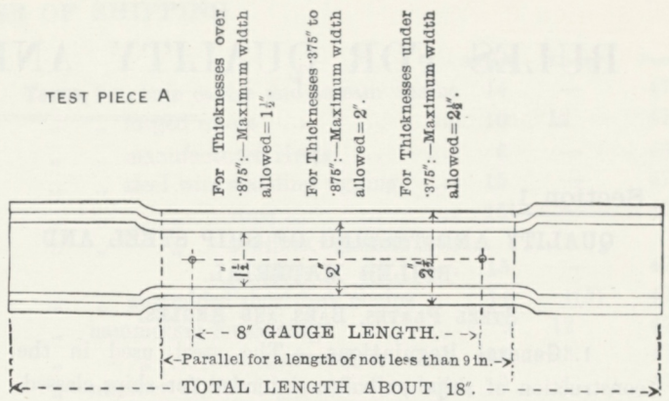
Section 2.

STANDARD TEST PIECES.

1. **Tensile Test Pieces.**—The tensile strength and ductility are to be determined from Standard test pieces cut lengthwise or crosswise from the rolled material. Where material is annealed or otherwise treated before despatch, the test pieces are to be similarly and simultaneously treated with the material before testing.

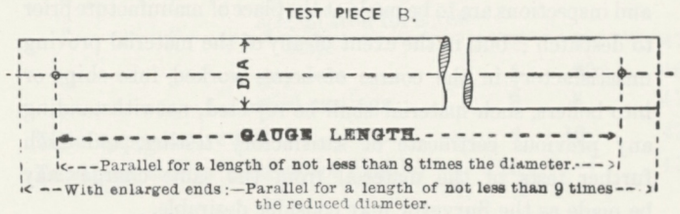
2. **Plates.**—(*a*) Wherever practicable the rolled surfaces are to be retained on two opposite sides of the test piece. The elongation is to be measured on a Standard test piece having a gauge length of 8 inches.

(*b*) For material more than ·875 inch in thickness the width of the test piece between the gauge points is not to exceed 1½ inches; or material ·875 inch to ·375 inch in thickness, inclusive, the width is not to exceed 2 inches; for material less than ·375 inch in thickness the width is not to be more than 2½ inches. In other respects the test pieces are to conform generally to the Standard test piece A.

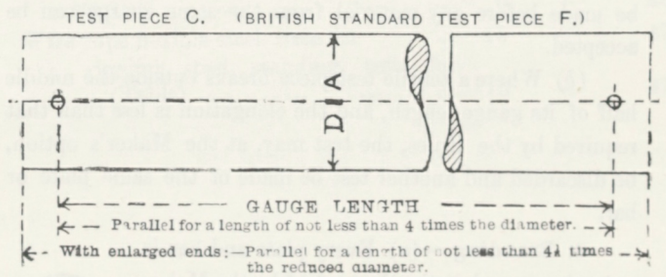


3. **Round Bars.**—(*a*) Bars may be tested full size as rolled, or they may be turned down to a convenient size, and if tested one inch in diameter, or under, the test piece is to have a gauge length of 8 times the diameter. Where enlarged ends are used the length of the parallel portion is not to be less than 9 times the reduced diameter of the test piece (*see* Standard test piece B).

The sectional area of the test piece is not to be less than ¼ square inch.



(*b*) Where bars are above one inch diameter, and are tested full size as rolled, or have been turned down and the resulting test piece is above one inch diameter, a gauge length of 4 times the diameter may be used if preferred by the Manufacturer, in which case an increased elongation will be required, as specified in Sections 5 and 6. Where enlarged ends are used, the length of the parallel portion is not to be less than 4½ times the reduced diameter (*see* Standard test piece C).



4. **Straightening of Test Pieces.**—Any straightening of test pieces A, B and C which may be required is to be done cold.

Section 3.

BEND TEST PIECES AND TESTS FOR SHIP AND BOILER STEEL.

1. **Number of Bend Tests for Ship Steel.**—A bend test is to be taken from each plate as rolled.

One bend test is to be made from each type of section and from each diameter of bar in every batch of 5 tons or part of 5 tons rolled from the same charge with a minimum of two bend tests per batch.

2. **Number of Bend Tests for Boiler Steel.** (*a*) **Plates.**—A bend test piece is to be taken from each plate as rolled. For plates exceeding 2½ tons in weight one bend test piece is to be taken from each end.

(*b*) **Angle Bars.**—A bend test is to be taken from each angle bar rolled.

(*c*) **Stay Bars.**—A bend test is to be made where a tensile test is required.

3. **Bend Test Pieces.**—(*a*) Test pieces are to be sheared lengthwise or crosswise from plates or bars, and are not to be less than 1½ inches wide, but for small bars the whole section may be used. For rivet bars bend tests are not required.

(*b*) In all bend tests, the rough edge or arris caused by shearing may be removed by filing or grinding, and test pieces one inch in thickness and above may have the edges machined, but the test pieces are to receive no other preparation. The test pieces are not to be annealed or otherwise heat treated unless the material from which they are cut is similarly heat treated, in which case the test pieces are to be similarly and simultaneously treated with the material before testing.

(*c*) For small sectional material these bend tests may be made from the flattened bar.

4. **Bend Tests.**—(*a*) The test piece is to withstand, without fracture, being doubled over until the internal radius is equal to 1½ times the thickness of the test piece, and the sides are parallel.

(*b*) Bend tests may be made either by pressure or by blows.

Section 4.

TESTS FOR SHIP STEEL.

1. **Specification.**—(*a*) The steel shall not contain more than ·06 per cent of sulphur or ·06 per cent phosphorus.

(*b*) For plates having a thickness greater than ½ inch the manganese content shall not be less than 2·5 times the carbon content.

(*c*) The chemical contents referred to in (*a*) and (*b*) above are to be determined from ladle analyses.

For special requirements *see* **Section 1, Clause 13.** For Regulations for Testing of Special Quality Steel for Shipbuilding *see* **Section 7.**

2. **Number of Tensile Tests. Plates and Sectional Material.**—When the Surveyor is in constant attendance at the Steel Works one tensile test piece for plates or sectional material is to be taken from the finished material of each charge.

Where the quantity of the material from one charge exceeds 25 tons, a second tensile test will be required; also additional tests are to be made for every variation in thickness of ·15 of an inch in the plates or sectional bars from each charge.

3. **Tensile Tests.** (*a*) **Plates.**—The tensile breaking strength of steel plates, determined from Standard test pieces, is to be between the limits of 26 and 32 tons per square inch. For plates specially intended for cold flanging and marked for identification, the tensile strength is to be between the limits of 26 and 30 tons per square inch. In the case of material for purposes in which tensile strength is not important, the tensile test may be dispensed with and the bend test only be made, if so specified by the builders and approved by the Committee. The elongation, measured on a Standard test piece having a gauge length of 8 inches, is not to be less than 20 per cent for material of ·375 inch in thickness and upwards, and not less than 16 per cent for material below ·375 inch in thickness.

(*b*) **Angles, Bulb Angles, Channels, and Similar Sections.**—The tensile breaking strength of angles, bulb angles, channels, and similar sectional material is to be between the limits of 26 and 32 tons per square inch. In the case of material for purposes in which tensile strength is not important, the tensile test may be dispensed with and the bend test only be made, if so specified by the builders and approved by the Committee. The elongation measured on a Standard test piece having a gauge length of 8 inches is not to be less than 20 per cent for material of ·375 inch in thickness and upwards, and not less than 16 per cent for material below ·375 inch in thickness.

For Bend Tests for Shipbuilding Steel *see* **Section 3.**

4. **Occasional Attendance at Steel Works (Steel for Shipbuilding Purposes).**—(*a*) When the Society's Surveyor is not in constant attendance at the Steel Works, the Makers themselves may, with the written authority of the Society, comply with all the prescribed requirements, and furnish the Surveyor with a certificate to the effect that the Society's Rules as to the testing of steel have been complied with in the case of the material submitted for approval.

The Surveyor is then to make check tensile and cold bend tests from not less than one bar in every batch of 50 or less in number, or not less than one plate in each batch of 25 or less in number, provided the batch be all from one charge.

Where more than one charge is represented, each charge is to be tested.

Additional tests are also to be made for every variation n thickness of ·15 of an inch made from one charge.

The test pieces are not to be taken from shearings previously detached from the plates or bars but are to be selected by the Surveyors from the plates or bars themselves, either in the sheared or unsheared condition. Should part of the material be presented in a sheared condition the selection of tests is not to be confined to the unsheared portion.

The samples when marked by the Surveyor for testing are to be followed, as far as practicable, through the different stages of preparation until the tests are completed.

A tensile and a cold bend test are to be taken crosswise from the centre part of the selected plate or plates at each end.

In addition to the tests prescribed above the material may be subjected to further tests at the discretion of the Surveyor.

(*b*) Where the tests are unsatisfactory, the whole of the material from the charge is to be rejected, and the Surveyor is to see that the Society's brand is satisfactorily defaced.

Section 5.

TESTS FOR STEEL FOR RIVETED BOILERS AND WELDED PRESSURE VESSELS.

1. All plates intended for cylindrical shells of pressure vessels which are to be welded, or where the thickness exceeds $1\frac{3}{4}$ inches, or where the internal diameters of the vessels are less than 100 times the thickness of the plates, should be efficiently normalised before the test pieces are cut off.

2. **Number of Tensile Tests.** (*a*) **Plates.**—One tensile test piece is to be taken from each plate as rolled. For plates exceeding $2\frac{1}{2}$ tons in weight one tensile test piece is to be taken from each end.

(*b*) **Angle, Tee and Stay Bars.**—One tensile test is to be made from each 15 or part of 15 bars rolled of each section or diameter from the same charge, but not less than two tensile tests are to be made unless the total number of bars rolled from the same charge is 8 or less than 8 and the bars are of the same section or diameter, in which case one tensile test will suffice. For round bars of $1\frac{3}{4}$ inch diameter and under, the numbers 50 and 20 are to be substituted for 15 and 8 respectively for determining the number of tests required.

3. **Tensile Tests.** (*a*) **Plates.**—The tensile breaking strength of steel shell plates, determined from Standard test pieces, is to be between the limits of 28 and 35 tons per square inch for riveted boilers, 26 and 35 tons per square inch for Fusion Welded Pressure Vessels and 26 and 30 tons per square inch for Forge Welded Pressure Vessels. *See* **clause 3** (*d*).

For girder plates the tensile breaking strength is to be between the limits of 28 and 35 tons per square inch.

For plates intended for flanging and for combustion chambers and furnaces, also for plates, other than shell plates, which are to be welded, the tensile breaking strength is to be between the limits of 26 and 30 tons per square inch.

A range of more than 4 tons per square inch will not be permitted in any one case. The elongation, measured on a Standard test piece having a gauge length of 8 inches, is not to be less than 20 per cent for material of ·375 inch in thickness and upwards required to have a tensile breaking strength between the limits of 28 and 35 tons per square inch ; and not less than 23 per cent for material of ·375 inch in thickness and upwards required to have a tensile breaking strength between the limits of 26 and 30 tons per square inch.

(*b*) **Angle and Tee Bars.**—The tensile breaking strength of angle and tee bars is to be between the limits of 28 and 32 tons per square inch, with an elongation of not less than 20 per cent measured on the Standard test piece A.

For plates, angles, or tee bars under ·375 inch in thickness the elongation may be 3 per cent, but not more than 3 per cent, below the prescribed elongations.

Wherever practicable the rolled surfaces are to be detained on two opposite sides of the test pieces.

(*c*) **Stay Bars.**—The tensile breaking strength of longitudinal stay bars is to be between the limits of 28 and 35 tons per square inch, with an elongation of not less than 20 per cent measured on the Standard test piece B, or 24 per cent measured on the Standard test piece C ; but a range of not more than 4 tons per square inch shall be permitted in any one case. For steel bars for combustion chamber stays the tensile breaking strength is to be between the limits of 26 and 30 tons per square inch, with an elongation of not less than 23 per cent measured on the Standard test piece B or 28 per cent measured on the Standard test piece C.

(*d*) **Special Quality Steel for Boilers.**—When steel material is proposed having other tensile strength than that specified in this Section, the proposed limits of tensile strength and elongation should be submitted for consideration.

In the case of forge welded cylindrical shells, material having tensile breaking strength between the limits of 24 and 28 tons per square inch, and elongation not less than 25 per cent on a gauge length of 8 inches will be accepted, the test pieces being taken crosswise from the plates as rolled.

Section 6.

TESTS FOR RIVET BARS AND MANUFACTURED RIVETS.

1. **Testing of Material.**—All material from which rivets are manufactured is to be tested.

Rivets are not to be manufactured from steel or ingot iron bars in which the sulphur segregates and other non-metallic substances are concentrated in the core. To ensure

this, a sulphur print is to be taken from the material of each charge, and where the weight of bars as rolled from one charge exceeds 10 tons, additional sulphur prints may be taken.

2. **Number of Tests.**—(*a*) In the case of steel bars, one tensile test piece is to be taken from each charge used for rivet bars; but where the weight of bars as rolled from one charge exceeds 10 tons, an additional tensile test is to be made from each further 10 tons or portion thereof.

(*b*) In the case of wrought iron bars, two tensile tests shall be taken from every three tons or portion thereof in each batch of any order presented for inspection, except that, in the case of lots of one ton or less, one tensile test shall be accepted.

(*c*) In the case of ingot iron bars, one tensile test piece is to be taken from each charge used for rivet bars; but where the weight of bars as rolled from one charge exceeds 10 tons, an additional tensile test is to be made from each further 10 tons or portion thereof.

(*d*) For rivet bars of steel or ingot iron one dump test is to be made for each tensile test.

3. **Tensile Tests.**—(*a*) The tensile breaking strength of steel rivet bars is to be between the limits of 26 and 30 tons per square inch of section with an elongation of not less than 25 per cent of the gauge length of eight times the diameter of the test piece, measured on the standard test piece B, or 30 per cent measured on the standard test piece C. The bars may be tested the full size as rolled.

(*b*) The tensile breaking strength of wrought iron rivet bars is to be between the limits of 21 and 25 tons per square inch. The elongation is to be not less than 22 per cent of the gauge length of eight times the diameter of the test piece, measured on the standard test piece B.

(*c*) The tensile breaking strength of ingot iron rivet bars is to be between the limits of 21 and 25 tons per square inch, with an elongation of not less than 25 per cent of the gauge length of eight times the diameter of the test piece, measured on the standard test piece B, or 30 per cent measured on the standard test piece C. The bars may be tested the full size as rolled.

4. **Dump Test.**—Short lengths, equal to twice their diameter, cut from the rivet bars shall, when cold, withstand without fracture being compressed to half their length.

5. **Nicked Bend Tests.**—(*a*) In the case of wrought iron bars one nicked bend test shall be taken from each three tons of material or portion thereof in each batch of any order presented for inspection.

(*b*) The test pieces shall be lightly and evenly nicked on one side with a sharp cutting tool, and bent back at this point through an angle of 180°. They shall show a clean fibrous fracture, free from slag or dirt or any coarse crystalline structure.

6. **Manufactured Rivets.**—Rivets selected by the Surveyor from the bulk are to withstand the tests described hereafter.

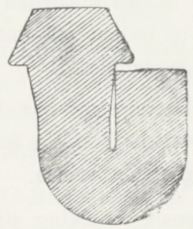


FIG. 1.

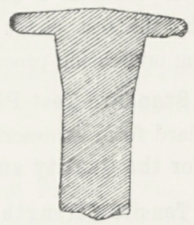


FIG. 2.

(*a*) The rivet shanks are to be bent cold, and hammered until the two parts of the shank touch in the manner shown in Fig. 1, without fracture on the outside of the bend.

(*b*) The rivet heads are to be flattened, while hot, in the manner shown in Fig. 2, without cracking at the edges. The heads are to be flattened until their diameter is $2\frac{1}{2}$ times the diameter of the shank.

(*c*) In the case of steel or ingot iron rivets, samples are to be selected by the Surveyor for examination by means of sulphur prints, to ensure that the material is free from marked central segregation.

Section 7.

SPECIAL QUALITY STEEL FOR SHIPBUILDING.

Regulations for Testing.

1. **Process of Manufacture.**—The steel is to be made by the Open Hearth Process, Acid or Basic, at works recognised by the Committee.

2. **Freedom from Defects.**—The finished material is to be free from cracks, surface flaws and laminations. It is also to have a workmanlike finish, and must not be hammer dressed.

3. **Testing and Inspection.**—The prescribed tests and inspections are to be made at the place of manufacture from the plates or bars in the condition in which they will be despatched; in the event of any of the material proving unsatisfactory in the course of being worked into the ships, such material shall be rejected, notwithstanding any previous certificate of satisfactory testing, and such further tests of the material from the same charge may be made as the Surveyor may consider desirable.

All test pieces are to be selected by the Surveyor and tested in his presence, and he is to satisfy himself that the prescribed conditions are fulfilled.

4. **Tensile Test Pieces.**—The tensile strength, ductility and limit of proportionality (as defined below) are to be determined from standard test pieces cut lengthways from the bar, and 50 per cent lengthways and 50 per cent crossways from the plate.

Where material is annealed or otherwise treated before despatch, the test pieces are not to be cut off until the annealing or treating process has been completed.

5. **Standard Test Pieces.**—The test pieces are all to be of standard form as described in **Section 2** of the Society's **Rules for the Quality and Testing of Materials.**

6. **Tensile Strength.**—The tensile breaking strength is not to exceed 38 tons per square inch, with a range of not more than 5 tons per square inch in any one case; the elongation is to be not less than 20 per cent measured on a gauge length of 8 inches.

7. **Limit of Proportionality.**—The material must satisfy a test for limit of proportionality of not less than 15 tons per square inch, the elastic properties being determined by means of a Ewing extensometer, or other approved extensometer, of 8 inch gauge length. The tests shall be carried out as follows:—

(*a*) A load of 2 tons per square inch of section shall be applied to the test piece and an extensometer reading taken.

(*b*) The load shall be increased to 15 tons per square inch of section and a second reading taken.

(*c*) The load shall be reduced to 2 tons per square inch and a third reading taken.

(*d*) The third reading shall not exceed the first reading by more than ·0004 inches.

8. **Number of Test Pieces.**—One tensile test piece is to be made from at least every fifth plate or bar, as rolled, from each charge. This test piece is to be used for determining both the limit of proportionality and the tensile strength. The Surveyor should select a sample from each variation of thickness of ·10 of an inch in the plates or bars from each charge.

9. **Cold Bend Tests.**—A cold bend test is to be taken both lengthways and crossways from every plate (bars lengthways only). The test pieces are to withstand without fracture, being doubled over until the internal radius is equal to one and a half times the thickness of the test pieces and the sides are parallel.

10. **Preparation of Test Pieces.**—The test pieces are to be carefully prepared in the usual manner.

11. **Additional Tests before Rejection.**—Where any of the test pieces first selected by the Surveyor do not fulfil the above requirements, two further tests of the same kind may be made from the same plate or bar, but where either of these fail the plate or bar from which the test pieces were cut is to be rejected.

In addition to the tests described above, the material may be subjected to further tests at the discretion of the Surveyor.

12. **Branding.**—In addition to the Manufacturer's name or Trade Mark and the place where made, and the numbers and identification marks laid down by the Society's Rules, each plate or bar is to be distinctly branded in two places with the Society's brand LR. and, in addition, with letters SPL, thus:—LR. SPL. in one stamp.

13. **Defacing of Material.**—In the event of the material failing, the brand is to be defaced in the usual manner.

14. **Submission of Plans.**—When it is desired to use this material in the construction of ships intended to be classed in the Society's Register Book, plans showing the reduction of scantlings proposed should be submitted for the consideration of the Committee.

15. **Alternative Proposals.**—The Committee will consider proposals for the use of special quality steel having limits different from those prescribed above, provided full particulars as to the properties and manufacture of the material are submitted for consideration.

Section 8.

SPECIAL IRON FOR SCREW STAYS FOR COMBUSTION CHAMBERS.

General.—In order that iron screw stays may be approved of the same size as would be required for mild steel the iron must withstand the tests described hereafter.

1. **Number of Tensile Tests.**—The bars as rolled are to be placed in batches of 20, and one tensile test piece is to be taken from each batch. If this is unsatisfactory, two other bars are to be selected for test, but should either of these fail the batch is to be rejected.

2. **Tensile Test.**—The tensile breaking strength is not to be less than 21½ tons per square inch, with an elongation of not less than 25 per cent measured on the Standard test piece B, or of 30 per cent measured on the Standard test piece C.

3. **Bend Tests.**—(*a*) Test pieces, either of the bar as rolled or turned down to one inch diameter, are to stand bending cold until the sides are parallel and the space between the two sides is not greater than the diameter of the test piece.

(*b*) One ordinary bend test piece is to be taken from each batch, and a similar test piece from each batch is to be lightly and evenly nicked on one side with a sharp cutting tool and bent back at this point through an angle of 180° by pressure or by a succession of light blows. The fracture must be clean, fibrous, free from slag or dirt or any coarse crystalline structure. If either of these tests is unsatisfactory, two other bars are to be selected for test, but should either of these fail the batch is to be rejected.

Section 9.

QUALITY AND TESTING OF STEEL CASTINGS.

1. **Process of Manufacture.**—Steel for castings is to be made by the Open Hearth process, Acid or Basic, or by such other process as may be approved by the Committee.

2. **Heat Treatment.**—All steel castings are to be thoroughly heat treated in a properly constructed furnace, which must permit of the whole casting being uniformly raised in temperature throughout its whole extent to the necessary intensity. The casting is to be allowed to cool prior to removal from the furnace, and if afterwards heated for any purpose it is again to be similarly heat treated if required by the Surveyor.

3. **Testing and Inspection.**—(*a*) The tests and inspections hereafter described are to be made, preferably at the place of manufacture prior to despatch, but in the event of any casting proving unsatisfactory in the course of preparation or erection, such casting is to be rejected notwithstanding any previous certificate of satisfactory testing.

(*b*) The tensile strength and ductility are to be determined from standard test pieces, which are to be prepared from pieces cast on the casting. These pieces are not to be cut or partially cut from the castings until the heat treatment of such castings has been completed, nor until they have been stamped by the Surveyor. The test pieces are to be stamped by the Surveyor after the heat treatment. All test pieces are to be selected by the Surveyor and tested in his presence, and he is to satisfy himself that the conditions herein described are fulfilled.

(*c*) Where the castings are to be used for purposes for which cast iron is ordinarily employed they need not be submitted to tensile and bend tests, but they are to be submitted to the hammering tests specified in **clause 12.**

4. **Number of Tests.**—At least one tensile test and one cold bend test are to be taken from each casting. In castings of complex design, referred to in **clause 11,** at least two tensile and two cold bend tests are to be taken. Where a casting is made from more than one charge of steel, at least four tensile and four cold bend tests are to be taken from pieces cast as far apart as possible on the casting, some test pieces being taken from as near the top, and others from as near the bottom of the casting as practicable. Where a number of charges are all mixed in one ladle before casting they may be considered as a single charge.

5. **Dimensions of Tensile Test Pieces.**—The tensile test pieces are to be turned so as to have a diameter of ·564 inch with a gauge length of 2 inches, or a diameter of ·798 inch with a gauge length of 3 inches, or a diameter of ·977 inch with a gauge length of $3\frac{1}{2}$ inches.

6. **Tensile Tests.**—The tensile breaking strength determined from test pieces of Standard dimensions is to be between the limits of 26 and 35 tons per square inch with an elongation of not less than 20 per cent measured on the Standard test piece.

7. **Dimensions of Bend Test Pieces.**—The bend test pieces are to be machined to a rectangular section one inch wide by $\frac{3}{4}$ inch thick, with the edges rounded to a radius of $\frac{1}{16}$th of an inch. They are to be bent over the thinner section. The bending may be performed either by pressure or by blows.

8. **Bend Tests.**—The bend test pieces are to withstand, without fracture, being bent cold through an angle of 120 degrees, the internal radius of the bend being not greater than one inch.

9. **Additional Tests before Rejection.**—Where either the tensile or bend test or both fail, and the Surveyor considers the fractured test piece or test pieces, or the results obtained therefrom, do not fairly represent the quality of the casting, duplicates of the test or tests which failed are to be made if requested by the Maker. In such cases the quality of the casting is to be judged by the result of the duplicate test or tests and not by the original test or tests which failed.

10. **Percussive Tests.**—Stern frames cast in one piece are to be let fall on hard ground (excavations being made to take bosses and other projections) after being raised through an angle of 45 degrees Stern frames cast in more than one piece, rudders, steering quadrants, crossheads and tillers, are to be dropped on hard ground from a height of from 7 to 10 feet according to the design, shape, and weight of the casting.

11. **Castings of Complex Design.**—Castings of complex design which would be liable to be deformed if submitted to the drop or percussive test, may have this test dispensed with provided two tensile and two cold bend tests are made upon pieces taken from positions as far apart as possible on each casting; one tensile and one bend test being taken from as near the top and the others from as near the bottom of the casting as practicable.

12. **Hammering Tests.**—All castings are to be slung up and well hammered to satisfy the Surveyors that the casting is sound and without flaw. For large castings the hammer used for this test is to be not less than 7 lb. weight. In the case of castings which are subjected to the percussive tests mentioned in **clause 10**, the hammering tests are to be applied after the percussive tests.

13. **Drilling Tests.**—In the case of large steel castings the Surveyors are to supplement the foregoing tests by drilling small holes at such parts of the castings where experience shows that cavities and contraction cracks are most likely to occur, and at positions which are to be agreed upon between the Surveyor and the Manufacturer, in order to determine the soundness or otherwise of the casting. These holes are afterwards to be tapped and properly filled up with screw plugs.

14. **Branding.**—Every casting, after it has withstood satisfactorily the prescribed tests, is to be clearly and distinctly marked by the Society's Surveyor indicating that the casting has complied with the Society's requirements.

Section 10.

QUALITY AND TESTING OF INGOT STEEL FORGINGS.

1. **Process of Manufacture.**—(*a*) Ingot steel for forgings is to be made by the Open Hearth process, Acid or Basic, or by such other process as may be approved by the Committee.

(*b*) The forgings are to be sound; they are to be made from sound ingots, and for all important forgings such as stern frames, rudder heads and main pieces of rudders upon which arms are shrunk, crank and other shafts connecting rods and piston rods, the forgings are to be gradually and uniformly forged. The sectional area of the body of the forging (as forged) is not to exceed one-fifth of the sectional area of the original ingot, and no part of the forging (as forged) is to have more than two-thirds of the sectional area of the original ingot.

(*c*) Where ingots are cast in chilled moulds with the larger diameter or cross section uppermost, and with efficient refractory feeder heads, the sectional area of any part of the forging (as forged) is not to exceed:—

(1) One-third of the sectional area of the ingot where the length of any diameter is greater than its diameter.

(2) Two-thirds of the sectional area of the ingot where the length at any diameter is less than its diameter, e.g., "a collar."

2. **Heat Treatment.** — All important ingot steel forgings are to be suitably heat treated in a properly constructed furnace, which must permit of the whole forging being uniformly heated throughout to the necessary temperature. If the forging be subsequently heated for any further forging, it is again to be similarly heat treated.

3. **Testing and Inspection.**—(*a*) The tests and inspections hereafter described are to be made, preferably at the place of manufacture prior to despatch, but in the event of any forging proving unsatisfactory in the course of preparation or erection, such forging is to be rejected notwithstanding any previous certificate of satisfactory testing.

(*b*) The tensile strength and ductility are to be determined from Standard test pieces which are to be prepared from sample pieces cut lengthwise from the forging from a part of not less sectional dimensions than the body of the forging. Such Standard test pieces are to be machined from the sample pieces without forging down, and the sample pieces are not to be detached from the forging until the heat treatment of such forging has been completed. The test pieces are to be stamped by the Surveyor after the heat treatment. All test pieces are to be selected by the Surveyor and tested in his presence, and he is to satisfy himself that the conditions herein described are fulfilled.

4. **Number of Tests.**—At least one tensile and one cold bend test piece are to be taken from each forging or multiple forging. In the case of forgings or multiple forgings exceeding both 3 tons in weight and 8 feet in length, one tensile and one cold bend test piece are to be taken from each end of each forging or multiple forging.

5. **Dimensions of Tensile Test Pieces.**—The tensile test pieces are to be turned so as to have a diameter of ·564 inch with a gauge length of 2 inches, or a diameter of ·798 inch with a gauge length of 3 inches, or a diameter of ·977 inch with a gauge length of 3½ inches.

In cases where the dimensions of the forging will not permit the use of one of these test pieces, any other standard round test piece can be used, provided it is of the largest practicable size and has a gauge length equal to four times the square root of the cross sectional area.

6. **Tensile Tests.**—(*a*) The tensile breaking strength determined from test pieces of Standard dimensions is to be between the limits of 28 and 40 tons per square inch, with a range not exceeding 4 tons per square inch in any one forging, and in no case is the sum of the tensile breaking strength and percentage of elongation, measured on the standard test piece, to be less than 57 for test pieces cut longitudinally. Where the tensile test pieces are required to be taken transversely this sum is to be not less than 52.

(*b*) Stern posts, propeller posts, rudders, and other ship forgings which are to be welded may be made of specially soft Open Hearth Ingot Steel instead of wrought iron, such steel to have a tensile breaking strength between the limits of 22 and 26 tons per square inch, with an elongation on the Standard test piece (**Section 10, clause 5**) of not less than 35 per cent for 22 ton steel and 31 per cent for 26 ton steel; in no case is the sum of the tensile breaking strength and corresponding elongation to be less than 57. The remaining tests and requirements are to be as prescribed for ordinary ingot steel.

7. **Dimensions of Bend Test Pieces.**—The bend test pieces are to be machined to a rectangular section one inch wide by $\frac{3}{4}$ inch thick, with the edges rounded to a radius of $\frac{1}{16}$th of an inch. They are to be bent over the thinner section The bending may be performed either by pressure or by blows.

8. **Bend Tests.**—The bend test pieces are to withstand, without fracture, being bent cold through an angle of 180 degrees, the internal radius of the bend being not greater than that specified below, for test pieces taken longitudinally :—

Up to 32 tons per square inch	$\frac{1}{4}$ in.
Above 32 tons and up to 36 tons per square inch	$\frac{3}{8}$ in.
Above 36 tons and up to 40 tons per square inch	$\frac{5}{8}$ in.

Where the test pieces are required to be taken transversely, the internal radius of the bend should be not greater than $\frac{1}{2}$ in., $\frac{3}{4}$ in. and $1\frac{1}{4}$ ins. respectively, for the tensile strengths as stated above.

9. **Additional Tests before Rejection.**—Where either the tensile or bend test, or both, fail, and the Surveyor considers the fractured test piece or test pieces, or the results obtained therefrom, do not fairly represent the quality of the forging, duplicates of the test or tests which failed are to be made if requested by the Maker. In such cases the quality of the forging is to be judged by the result of the duplicate test or tests and not by the original test or tests which failed.

10. **General.**—The requirements as to heat treatment and testing are intended to apply to rudder heads and main pieces of rudders upon which arms are shrunk, to shafts of all descriptions, also to connecting rods and piston rods which require to be made in several heats. They are not intended to apply to small forgings which during their last stage of manufacture are uniformly heated throughout.

11. **Special Quality Steel for Forgings.**—Where steel material is proposed having other tensile strength than that specified in this Section, the particulars of the mechanical properties of the material should be submitted for consideration.

12. **Forged Rotors.**—In the case of forged rotors which rotate at a peripheral speed greater than 600 feet per second, longitudinal, tangential and radial sets of test pieces, each set comprising tensile and bend tests should be taken and the proposed mechanical properties should be submitted for consideration.

13. **Branding.**—Every forging after it has withstood satisfactorily the prescribed tests, is to be clearly and distinctly marked by the Society's Surveyor indicating that the forging has complied with the Society's requirements.

Section 10A.

SEAMLESS STEEL DRUMS FOR BOILERS.

1. **Process.**—The Steel is to be made by the Open Hearth Process, Acid or Basic.

2. **Discard.**—Sufficient discard shall be made from the top and bottom of each ingot to ensure soundness in the portion used for forging, and sulphur prints may be taken to demonstrate that this condition has been fulfilled.

3. **Forging.**—The forging shall be made from a solid cast ingot, punched, bored or trepanned, or alternatively hollow cast ingots may be used. The resultant wall in the case of the solid cast ingot, or the wall of the hollow ingot, as cast, shall be reduced in thickness by at least two-thirds in the process of forging.

The Committee will be prepared to give consideration to the circumstances of any special case.

4. **Heat Treatment and Testing.**—Sufficient material shall be left on each end of each forging to enable tangential tests to be taken. These tests are to consist of one tensile and one bend test from each end. In the case of open-ended drums the test material shall not be parted off before heat treatment, but if the drums are closed in the test rings may be parted prior to this operation ; subsequently the test rings and the forging shall be simultaneously heat treated in the same furnace.

If desired, test pieces may be heated for the purpose of straightening, but this operation must not cause any alteration in the sectional area of the test pieces, which are subsequently to be heat treated simultaneously with the drum.

5. **Mechanical Tests.**—The forging shall conform to the following requirements :—

Tensile strength 28 to 40 tons per square inch, but the difference in the tensile strength between the ends of each forging is not to exceed 4 tons per square inch.

Elongation 29 per cent. to 17 per cent. on standard test piece as per **Section 10, clause 5.** In no case is the sum of the tensile breaking strength and corresponding elongation to be less than 57.

Bend Test :—Test pieces 1 in. by $\frac{3}{4}$ in. to be capable of being bent cold through an angle of 180°, the internal radius of the bend being not greater than that specified below :—

Up to 32 tons per square inch	$\frac{1}{4}$ in.
Above 32 tons and up to 36 tons per square inch	$\frac{3}{8}$ in.
Above 36 tons and up to 40 tons per square inch	$\frac{5}{8}$ in.

6. **Retesting.**—Should either a tensile or bend test fail, two further specimens may be tested and if the results obtained from both are satisfactory the forging shall be accepted. In the event of either or both retests failing, the forging may be again heat treated and re-presented for test.

Section 11.

QUALITY AND TESTING OF BRONZE PROPELLERS AND BRONZE PROPELLER BLADES.

1. **Number of Tests.**—At least one tensile test is to be taken from each casting.

2. **Dimensions of Test Piece.**—The tensile test pieces are to be turned so as to have a diameter of ·564 inch or ·798 inch, with a gauge length of two inches.

3. **Tensile Tests.**—The tensile breaking strength determined from test pieces of standard dimensions is to be not less than 28 tons per square inch, and the sum of the tensile breaking strength and percentage of elongation measured on the standard test piece, is to be not less than 48. In no case, however, is the percentage of elongation to be less than 15.

Section 12.

QUALITY AND TESTING OF ANCHORS FOR STEAM SHIPS, SAILING SHIPS AND TUGS.

1. **Process of Manufacture.**—(*a*) Anchors are to be made of forged wrought iron, or forged open hearth ingot steel, or cast steel; the use of Bessemer steel is prohibited.

(*b*) Each important part of a forged anchor is to be plainly marked by the Makers with the words "Forged Wrought Iron," or "Forged Open Hearth Ingot Steel," as the case may be.

(*c*) Steel Anchor Shackles are to be forged and unwelded, or may be of cast steel provided the material of which they are manufactured complies with **Section 9** of the **Rules for Quality and Testing of Materials.**

2. **Tests of Anchors.**—All anchors, including Stream and Kedge anchors weighing more than 168 lbs. inclusive of stock, are to be tested in accordance with the requirements of the following Table and the Certificates of Test produced.

WEIGHTS AND CORRESPONDING PROOF STRAINS OF ANCHORS.

Weight.	Test.	Weight.	Test.	Weight.	Test.	Weight	Test.	Weight.	Test.	Weight.	Test.
Cwts.	Tons.	Cwts.	Tons.	Cwts.	Tons.	Cwts.	Tons.	Cwts.	Tons.	Cwts.	Tons.
1¼	3 13/20	7¼	9 9/20	14½	16 1/20	30	28 12/20	48¾	41 11/20	94½	65 3/20
1½	3 18/20	7½	9 13/20	15	16 10/20	30½	29	49½	42 1/20	95	65 7/20
1¾	4 4/20	7¾	9 18/20	15¼	16 14/20	31	29 7/20	51	43	98	66 10/20
2	4 10/20	8	10 2/20	16¼	17 11/20	32	30 2/20	52½	43 18/20	100	67 5/20
2¼	4 15/20	8¼	10 7/20	16¾	18	32½	30 10/20	54½	45 1/20	101½	67 16/20
2½	5	8½	10 12/20	17	18 5/20	33	30 17/20	56¼	46 3/20	104½	68 19/20
2¾	5 5/20	8¾	10 17/20	17½	18 12/20	33½	31 5/20	58	47 5/20	105½	69 6/20
3	5 10/20	9	11 2/20	18¾	19 13/20	34	31 12/20	60	48 7/20	109	70 12/20
3¼	5 14/20	9¼	11 6/20	19	19 17/20	35½	32 15/20	61½	49 3/20	109½	70 16/20
3½	5 18/20	9½	11 11/20	20½	21 3/20	36	33 2/20	63¾	50 7/20	113½	72 6/20
3¾	6 3/20	9¾	11 15/20	21	21 12/20	36½	33 8/20	65	51	118	74
4	6 7/20	10	12	21¼	21 16/20	37¼	33 18/20	68	52 12/20	122½	75 10/20
4¼	6 12/20	10¼	12 4/20	22	22 7/20	38	34 10/20	68½	52 18/20	127	76 18/20
4½	6 17/20	10½	12 8/20	22½	22 15/20	38¾	34 19/20	72	54 15/20	132	78 10/20
4¾	7 2/20	10¾	12 13/20	23¼	23 6/20	39	35 2/20	72½	55	137	80 1/20
5	7 7/20	11	12 17/20	23½	23 10/20	40	35 15/20	76	56 15/20	142	81 12/20
5¼	7 11/20	11¼	13 2/20	24½	24 6/20	40¾	36 6/20	77	57 5/20	147½	83 6/20
5½	7 16/20	11½	13 7/20	25	24 15/20	42	37 2/20	80	58 10/20	153	85
5¾	8	11¾	13 12/20	25½	25 3/20	42½	37 10/20	81¼	59 2/20	159	86 10/20
6	8 5/20	12	13 17/20	26½	26	44¼	38 15/20	83½	60 5/20		
6¼	8 10/20	12½	14 6/20	27¾	26 18/20	45	39 5/20	85½	61 5/20		
6½	8 15/20	13	14 15/20	28	27 2/20	46	39 17/20	87	61 17/20		
6¾	9	13½	15 3/20	28½	27 10/20	47¾	40 19/20	90	63 5/20		
7	9 5/20	14	15 12/20	29½	28 5/20	48	41 2/20	91	63 12/20		

The weight given in the above Table is either for stockless anchors or for the ordinary type excluding stock. For intermediate weights of anchors the tests may be obtained by interpolation.

Section 13.

CAST STEEL ANCHORS.

1. **General.**—All cast steel anchors in addition to undergoing the statutory tests are to be subjected to the percussive, hammering and bending tests given below.

These tests are to be carefully and completely made in the presence and to the satisfaction of the Society's Surveyors.

2. **Percussive Test.**—(*a*) The anchor, or where anchors are made in more than one piece, each piece is to be raised a given height and then dropped on a steel or iron slab.

For weights of 15 cwts. and below, the height is to be 15 feet, and for weights above 15 cwts. the height is to be 12 feet.

The lowest part of the anchor or piece when suspended is to be at least the given height above the iron slab upon which it is to be dropped.

(*b*) An anchor of the Admiralty pattern is first to be raised vertically to the given height with its shank and arms in a horizontal position, and then let fall from that height.

It is then to be raised a second time to the given height and suspended with the crown downwards. Two steel or iron blocks are to be placed underneath it, and the anchor is to be let fall from this position so that one of the blocks receives it on the middle of one arm, and the other block receives it on the middle of the other arm.

(*c*) The slab for the horizontal test is to be of steel or iron, well laid on a solid concrete foundation to the satisfaction of the Surveyor.

(*d*) If the slab on which the anchor falls is broken by the impact the test is to be repeated until a slab is made that does not break.

(*e*) The blocks for the vertical test are to be solid and of sufficient height to prevent the crown of the anchor from touching the slab, and are to be to the satisfaction of the Surveyor.

3. **Hammering Test.**—Provided the percussive test has been satisfactory, the anchor or piece is to be slung and thoroughly hammered over its parts with a sledge hammer weighing not less than 7 lb., and is required to give under this treatment such a clear ring in all its parts as shall satisfy the Surveyor that the casting is sound and that no flaws have developed by the application of the preceding percussive tests.

4. **Bending Test.**—(*a*) Cast steel may be passed as sufficiently ductile for anchors when a piece of each casting 8 inches in length, is cut from the casting, turned to one inch in diameter, and is then bent cold by hammering through an angle of 90 degrees over a radius of $1\frac{1}{2}$ inches, without showing signs of flaw or fracture.

(*b*) A piece is to be cast on each cast steel anchor or on each portion of such anchor when it is made of more than one casting, and each piece is to be of sufficient size to enable one test piece of the size stated above to be cut out of it, or it may be (at the discretion of the Manufacturer) of sufficient size to enable four test pieces to be cut out of it.

Where it is only of sufficient size to enable one test piece to be cut out of it, that piece is to be subjected to the bending test named in paragraph (*a*) above, and should it fail to withstand the test the casting is to be rejected.

Where the piece is large enough to enable four test pieces to be cut out of it, one of these is to be turned in a lathe to one inch in diameter for a length of 8 inches, and bent cold through an angle of 90° over a radius of $1\frac{1}{2}$ inches, and should the piece withstand this test without flaw or fracture it shall be deemed to have withstood a satisfactory test for ductility.

Should the one test piece not pass this test, all or any of the other three test pieces may be tested in a similar manner, and should any one of the four test pieces pass this test, the anchor, or part of the anchor, as the case may be, shall be deemed so far satisfactory.

5. **Heat Treatment.**—Each anchor is to be thoroughly heat treated and marked "Annealed Steel."

Section 14.

TESTS FOR CHAIN CABLES AND STREAM CHAINS.

1. **Tests for Chain Cables and Stream Chains.**—(*a*) All stud link chain cables and stream chains are to be tested in accordance with the requirements of the following Table and the certificates of test produced.

STUD LINK CHAIN CABLES.

Minimum Size.	Cables of Wrought Iron.		Cables of Special Steel.		Minimum Weight per length of 15 fms.	Minimum Size.	Cables of Wrought Iron.		Cables of Special Steel.		Minimum Weight per length of 15 fms.
	Proved to Statutory Test.	Breaking Test.	Proved to Statutory Test.	Breaking Test.			Proved to Statutory Test.	Breaking Test.	Proved to Statutory Test.	Breaking Test.	
Ins.	Tons.	Tons.	Tons.	Tons.	Cwts.	Ins.	Tons.	Tons.	Tons.	Tons.	Cwts.
7/16	3 4/10	5 1/10	4 8/10	7 1/10	1 3/4	2	72	100 8/10	100 8/10	141 1/10	30
8/16	4 5/10	6 3/4	6 3/10	9 5/10	2 1/8	2 1/16	76 5/10	107 1/10	107 1/10	149 9/10	31 7/8
9/16	5 5/8	8 4/10	7 9/10	11 8/10	2 5/8	2 2/16	81 1/4	113 3/4	113 3/4	159 3/10	33 3/4
10/16	7	10 5/10	9 8/10	14 7/10	3 1/4	2 3/16	86 1/8	120 5/10	120 5/10	168 7/10	35 7/8
11/16	8 5/10	12 3/4	11 9/10	17 [9]1/10	3 5/8	2 4/16	91 1/8	127 5/10	127 5/10	178 5/10	37 7/8
12/16	10 1/8	15 1/8	14 2/10	21 2/10	4 3/8	2 5/16	96 1/4	134 3/4	134 3/4	188 3/4	40
13/16	11 7/8	17 8/10	16 6/10	24 9/10	5 1/8	2 6/16	101 5/10	142 1/10	142 1/10	198 9/10	42 1/4
14/16	13 3/4	20 5/8	19 3/10	28 9/10	5 7/8	2 7/16	106 9/10	149 5/8	149 5/8	209 5/10	44 1/2
15/16	15 8/10	23 7/10	22 1/10	33 2/10	6 3/4	2 8/16	112 5/10	157 5/10	157 5/10	220 5/10	47
1	18	27	25 2/10	37 8/10	7 5/8	2 9/16	116 7/10	163 3/8	163 3/8	228 7/10	49 1/2
1 1/16	20 3/10	30 4/10	28 4/10	42 6/10	8 5/8	2 10/16	120 9/10	169 1/4	169 1/4	237	52
1 2/16	22 3/4	34 1/8	31 9/10	47 8/10	9 3/4	2 11/16	125 1/10	175 1/8	175 1/8	245 2/10	54 1/2
1 3/16	25 3/8	38	35 5/10	53 2/10	10 7/8	2 12/16	129 3/10	181	181	253 4/10	57 1/8
1 4/16	28 1/8	42 1/8	39 4/10	59	12	2 13/16	133 4/10	186 3/4	186 3/4	261 5/10	59 7/8
1 5/16	31	46 1/2	43 4/10	65 1/10	13 1/4	2 14/16	137 6/10	192 5/8	192 5/8	269 7/10	62 5/8
1 6/16	34	51	47 6/10	71 4/10	14 1/2	2 15/16	141 7/10	198 3/8	198 3/8	277 7/10	65 1/2
1 7/16	37 1/8	55 5/8	52	77 9/10	15 7/8	3	145 8/10	204 1/10	204 1/10	285 7/10	68 3/8
1 8/16	40 5/10	58 7/10	56 7/10	82 2/10	17 1/4	3 1/16	149 8/10	209 7/10	209 7/10	293 6/10	71 1/4
1 9/16	43 9/10	61 4/10	61 4/10	86	18 3/4	3 2/16	153 3/4	215 1/4	215 1/4	301 4/10	74 1/4
1 10/16	47 5/10	66 5/10	66 5/10	93 1/10	20	3 3/16	157 7/10	220 3/4	220 3/4	309 1/10	77 3/8
1 11/16	51 1/4	71 3/4	71 3/4	100 5/10	21 1/2	3 4/16	161 6/10	226 2/10	226 2/10	316 7/10	80 3/8
1 12/16	55 1/8	77 1/8	77 1/8	108	23 1/8	3 5/16	165 4/10	231 5/10	231 5/10	324 1/10	83 5/8
1 13/16	59 1/8	82 3/4	82 3/4	115 9/10	24 7/8	3 6/16	169 1/8	236 3/4	236 3/4	331 5/10	86 7/8
1 14/16	63 1/4	88 5/10	88 5/10	123 9/10	26 5/8	3 7/16	172 3/4	241 8/10	241 8/10	338 5/10	90 1/8
1 15/16	67 5/10	94 5/10	94 5/10	132 3/10	28 3/8	3 8/16	176 4/10	246 9/10	246 9/10	345 7/10	93 1/2

(*b*) Unstudded close-link chains will be accepted as cables if tested in accordance with the requirements of the following Table and the certificates of test produced.

WROUGHT IRON SHORT LINK CHAIN CABLES.

Minimum Size.	Proved to Statutory Test.	Breaking Test.	Minimum Weight per length of 15 fms.	Minimum Size.	Proved to Statutory Test.	Breaking Test.	Minimum Weight per length of 15 fms.
Ins.	Tons.	Tons.	Cwts.	Ins.	Tons.	Tons.	Cwts.
$\frac{7}{16}$	$2\frac{1}{4}$	$4\frac{1}{2}$	2	$1\frac{4}{16}$	$18\frac{3}{4}$	$37\frac{1}{2}$	$12\frac{7}{8}$
$\frac{8}{16}$	3	6	$2\frac{1}{2}$	$1\frac{5}{16}$	$20\frac{5}{8}$	$41\frac{1}{4}$	$14\frac{1}{8}$
$\frac{9}{16}$	$3\frac{3}{4}$	$7\frac{1}{2}$	3	$1\frac{6}{16}$	$22\frac{5}{8}$	$45\frac{1}{4}$	$15\frac{1}{2}$
$\frac{10}{16}$	$4\frac{5}{8}$	$9\frac{1}{4}$	$3\frac{1}{2}$	$1\frac{7}{16}$	$24\frac{3}{4}$	$49\frac{1}{2}$	17
$\frac{11}{16}$	$5\frac{5}{8}$	$11\frac{1}{4}$	4	$1\frac{8}{16}$	27	54	$18\frac{3}{8}$
$\frac{12}{16}$	$6\frac{3}{4}$	$13\frac{1}{2}$	$4\frac{3}{4}$	$1\frac{9}{16}$	$29\frac{1}{4}$	$58\frac{1}{2}$	$19\frac{7}{8}$
$\frac{13}{16}$	$7\frac{9}{10}$	$15\frac{8}{10}$	$5\frac{1}{2}$	$1\frac{10}{16}$	$31\frac{5}{8}$	$63\frac{1}{4}$	$21\frac{1}{2}$
$\frac{14}{16}$	$9\frac{1}{8}$	$18\frac{1}{4}$	$6\frac{3}{8}$	$1\frac{11}{16}$	$34\frac{1}{8}$	$68\frac{1}{4}$	$23\frac{1}{8}$
$\frac{15}{16}$	$10\frac{1}{2}$	21	$7\frac{1}{4}$	$1\frac{12}{16}$	$36\frac{3}{4}$	$73\frac{1}{2}$	25
1	12	24	$8\frac{1}{4}$	$1\frac{13}{16}$	$39\frac{4}{10}$	$78\frac{8}{10}$	$26\frac{7}{8}$
$1\frac{1}{16}$	$13\frac{1}{2}$	27	$9\frac{1}{4}$	$1\frac{14}{16}$	$42\frac{1}{8}$	$84\frac{1}{4}$	$28\frac{7}{8}$
$1\frac{2}{16}$	$15\frac{1}{8}$	$30\frac{1}{4}$	$10\frac{3}{8}$	$1\frac{15}{16}$	45		$30\frac{7}{8}$
$1\frac{3}{16}$	$16\frac{9}{10}$	$33\frac{8}{10}$	$11\frac{5}{8}$	2	48	96	33

Section 15.

TESTS FOR STEEL WIRE TOWLINES, HAWSERS AND WARPS, AND STANDING RIGGING.

1. **General.**—Each Manufacturer is required to provide on his premises machines suitable for making the prescribed tests satisfactorily, and the works are to be at all times open to the inspection of the Society's Surveyors, who are empowered to retest any rope for which a certificate has been issued by the Manufacturer. Periodical inspections should be held at intervals not exceeding two years.

2. **Certificates.**—Printed forms of certificates, approved by the Committee, are to be signed by the Manufacturers and will be supplied to them upon application to the Secretary.

3. **Material.**—The wire used in the manufacture of the ropes is to be drawn from steel billets made by the Open Hearth Process, and is to have the following ultimate tensile strength :—

For standing rigging wire ropes 45 to 55 tons per square inch, for tow lines, hawsers and warps 80 to 95 tons per square inch. The wire is to be of homogeneous quality, free from defects, and of smooth uniform finish.

4. **Galvanising.**—The wire is to be galvanised to the satisfaction of the Surveyors.

5. **Construction of Ropes.**—(*a*) Steel wire rope for standing rigging is to be composed of six strands each of seven wires (6 over 1), the strands being closed over a fibre core ; no fibre is to be used in the strands.

(*b*) Steel wire rope for tow lines, hawsers and warps may be of flexible construction of 6 strands, each of 12 wires laid round a fibre centre, the strands being closed over a fibre core ; or of special flexible construction of 6 strands each of 24 wires (15 over 9 over a fibre centre), the strands being closed over a fibre core ; or of special flexible construction of 6 strands each of 30 wires (18 over 12 over a fibre centre), the strands being closed over a fibre core.

6. **Tests.**—A portion of each steel wire rope is to be tested to destruction and its ultimate breaking load must not be less than that prescribed in the Table. If facilities are not available for making this test on the rope, then a specimen is to be cut from the rope and each wire tested separately to destruction.

In this case the minimum breaking load of the rope shall be considered to be the sum of the aggregate breaking loads of the individual wires, less a percentage for laying up, as follows :—

6 × 7	5 per cent.
6 × 12	7½ „
6 × 24	10 „
6 × 30	12½ „

The wire shall stand being wrapped tightly eight times around its own diameter, and subsequently unwrapped without showing any signs of fracture of the steel. Six wires, or 5 per cent of the wires in the rope, whichever is the greater, are to be subjected to this test.

SIZES AND BREAKING TESTS OF STEEL WIRE ROPES.

Circumference of Ropes.	Galvanised Standing Rigging Wire Ropes.	Galvanised Flexible Wire Ropes.	Galvanised Special Flexible Wire Ropes.	
	(*a*)	(*b*)	(*c*)	(*d*)
	6×7	6×12	6×24	6×30
Inches.	Tons.	Tons.	Tons.	Tons.
1	1·8	2·0	2·6	2·6
1¼	2·9	3·1	4·4	3·6
1½	4·2	4·8	6·1	5·4
1¾	5·8	6·4	8·7	7·5
2	7·6	8·3	11·2	10·0
2¼	9·5	10·8	14·7	12·8
2½	11·8	13·2	17·7	15·2
2¾	14·3	15·2	21·1	19·6
3	17·1	18·6	25·7	23·5
3¼	20·1	21·7	29·7	25·6
3½	23·4	25·7	35·2	30·1
3¾	26·9	29·3	39·9	34·9
4	30·3	33·2	44·9	40·1
4¼	34·3	36·4	51·5	45·6
4½	38·5	43·3	58·6	51·4
4¾	43·0	47·0	64·6	57·6
5	47·6	52·8	70·9	64·2
5¼	52·3	57·6	77·5	71·2
5½	57·0	62·4	84·4	76·6
5¾			91·5	82·3
6			99·1	92·1
6¼			104·5	98·3
6½			112·3	104·7
6¾			120·3	111·2
7			130·7	120·0
7½				131·8
8				148·8

71, FENCHURCH STREET, LONDON, E.C.3.

15*th December*, 1949.

Section 16.

QUALITY AND TESTING OF STEEL FOR PRESSURE PIPES AND SMOKE TUBES.

1. **Material.**—The steel is to be made by the open hearth process.

2. **Tests.**—

(*a*) **Seamless Pipes.**—The tensile strength of the steel is to be between 23 and 30 tons per square inch, with a minimum elongation of 20 per cent on a standard test piece having a gauge length of 8 inches.

(*b*) **Lap Welded Pipes.**—The tensile strength of the steel is to be between 22 and 28 tons per square inch, with a minimum elongation of 25 per cent on a standard test piece having a gauge length of 8 inches.

(*c*) **Smoke Tubes.—Lap Welded or Seamless.**—The tensile strength of the material is not to exceed 28 tons per square inch, with a minimum elongation of 20 per cent on a standard test piece having a gauge length of 8 inches.

TENTATIVE REQUIREMENTS

for

QUALITY AND TESTING OF ALUMINIUM ALLOYS FOR SHIPBUILDING PURPOSES.

Tentative Requirements for QUALITY AND TESTING OF ALUMINIUM ALLOYS FOR SHIPBUILDING PURPOSES.

The following Requirements are not intended to apply to sheet alloy less than ·18 inch thick, or to small sections. Where material of these scantlings is used, the physical properties and chemical composition may be in accordance with a recognised specification for an alloy suitable for marine use.

Section 1.

ALUMINIUM ALLOY PLATES AND SECTIONS.

1. **General.**—Aluminium alloys used in the construction of ships classed, or proposed for classification, in the Society's Register Book, are to comply with the following requirements.

2. **Freedom from Defects.**—The finished material is to be free from cracks, surface flaws and lamination.

3. **Testing and Inspection.**—(*a*) The prescribed tests and inspections are to be made at the place of manufacture prior to despatch; but, in the event of any material proving unsatisfactory in the course of being worked into ships due to faults in manufacture, such material shall be rejected, notwithstanding any previous certificate of satisfactory testing, and such further tests of the material from the same cast may be made as the Surveyor may consider desirable.

Where a continuous melting process is employed for the production of ingots, a cast is to be defined as the amount of metal tapped from the furnace without any further addition having been made.

(*b*) All test pieces are to be selected by the Surveyor and tested in his presence, and he is to satisfy himself that the prescribed conditions are fulfilled.

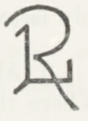
(*c*) The Manufacturer is to supply to the Surveyor at the time of test a certificate of the chemical composition of the material submitted for approval and, at the discretion of the Surveyor, samples may be selected from the material for the purpose of check analyses.

4. **Additional Tests before rejection.**—(*a*) Where any of the test pieces first selected by the Surveyor do not fulfil the test requirements, then:—

(1) In the case of non heat-treatable alloys, two further tests of the same kind may be made from the same plate, or section, but where either of these fail, the plate or section from which the test pieces were cut is to be rejected. In all such cases further tests are to be taken before any material from the same cast can be accepted.

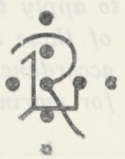
(2) In the case of heat-treatable alloys, the procedure laid down in (1) above is to be adopted, but the Manufacturer may, should he so desire, re-heat the whole of the material represented by the test piece before the two further test pieces are selected.

(*b*) Where a tensile test piece breaks outside the middle half of its gauge length, and the elongation is less than that required by the Rules, the test may, at the manufacturers' option, be discarded and another test made of the same plate or section.

5. **Branding.**—(*a*) Every plate or section is to be clearly and distinctly marked by the Manufacturer in two places with the Society's Brand, thus:—  indicating that the material has complied with the Society's requirements.

(*b*) Material bearing this brand is not to be forwarded from the Works until the prescribed tests have been made by the Surveyor and the mill sheets have been signed by him. All material is also to be

stamped in two places with the Manufacturer's name or trade mark and the place where made. Material is also to be stamped with numbers, or identification marks, by which it can be traced to the cast from which it was made.

6.—**Defacing of Rejected Material.**—In the event of the material failing to withstand the prescribed tests, the Surveyor is to see that the Society's brand, stamped on the plates by the Manufacturer, has been defaced by punch marks extending beyond the brand in the form of a cross, thus:—  denoting that the material has been rejected.

7. **Manufacturer's Certificate.**—The mill sheets, presented to the Surveyor for signing, shall bear the following certificate printed on each sheet, with the name of the firm and initialled by the Test House Manager:—

"We hereby certify that the material described below satisfies the prescribed chemical composition and is that which has been satisfactorily tested in the presence of the Surveyor in accordance with the Rules of Lloyd's Register."

8. **Facilities for Inspection.**—The Manufacturer is to adopt a system of marking which will enable all material presented for inspection to be traced to the original cast, and, in the case of heat-treatable material, to the particular batch in which it was heat-treated; a batch comprises all material simultaneously heat-treated in one furnace load. The Surveyor must be given every facility for tracing all material to its respective casts and for witnessing the required tests. When the Surveyor is satisfied with the material and with the results of tests, he is to be furnished with two copies of the advice notes for his signature, one of which is to be forwarded by the Manufacturer to the Shipbuilder, and the other is to be forwarded by the Surveyor to the Surveyors at the port where the ship is to be built.

9. **Aluminium Alloys not made where wrought.**—Where the alloy is not made at the Works where it is wrought, a certificate is to be supplied to the Surveyor stating the name of the Maker of the material, also the numbers of the casts for reference to the books of the Maker. The number of the cast is to be marked on each ingot or slab for the purpose of identification and the wrought material is also to be legibly stamped in two places with the Manufacturer's name or trade mark and the place where finally wrought. The material is also to be stamped with numbers or identification marks by which it can be traced to the cast from which it was made.

10. **General.**—In addition to the test described hereafter, the material may be subjected to additional tensile tests at the discretion of the Surveyors.

11. **Aluminium Alloys of other Chemical Composition or Mechanical Properties.**—When desired by Owners and Builders, consideration will be given by the Committee to proposals for the use of Alloys differing in chemical composition or mechanical properties from those provided for in the Rules.

Section 2.

STANDARD TEST PIECES.

1. **Tensile Test Pieces.**—The proof stress, the tensile strength and the ductility are to be determined from standard test pieces. The test for proof stress shall be carried out on each selected test piece either:—

(*a*) from a stress strain curve, by drawing a line parallel to the straight portion of the curve and distant from it by an amount representing the required maximum permanent elongation, thus determining the stress at which line and curve intersect, or

(*b*) by subjecting the test piece to the specified minimum proof stress and removing the load, when the test piece shall not have acquired a permanent elongation, measured by an extensometer, greater than that required by the Rules.

2. **Plates and Sections.**—(*a*) Wherever practicable, the wrought surfaces are to be retained on two opposite sides of the test piece. The elongation is to be measured on a gauge length of 8 inches.

(*b*) For material more than ·875 inch in thickness the width of the test piece between the gauge points is not to exceed 1½ inches; for material ·875 inch to ·375 inch in thickness, inclusive, the width is not to exceed 2 inches; for material less than ·375 inch in thickness the width is not to exceed 2½ inches. In other respects the test pieces are to conform to Standard Test Piece A. (*See* Rules for Quality and Testing of Materials, Section 2).

3. **Straightening of Test Pieces.**—Any straightening of test pieces which may be required is to be done cold, and the test pieces shall not receive further heat treatment or mechanical working before being tested except by machining to shape.

Section 3.

TESTS AND REQUIREMENTS FOR ALUMINIUM ALLOYS.

Plates and Sections. 1. **Chemical Composition.**—(*a*) Plates and sections where of non heat-treatable aluminium alloy are to have the following chemical composition :—

Copper	...	not more than	0·10	per	cent.
Magnesium	...	„ „ „	5·50	„	„
Iron	... ...	„ „ „	0·75	„	„
Silicon	...	„ „ „	0·60	„	„
Manganese	...	„ „ „	1·00	„	„
Chromium	...	„ „ „	0·50	„	„
Zinc	... ...	„ „ „	0·10	„	„

(*b*) Plates and sections of heat-treatable aluminium alloy are to have the following chemical composition :—

Copper	...	not more than	0·10	per	cent.
Magnesium	...	„ „ „	1·50	„	„
Iron	... ...	„ „ „	0·60	„	„
Silicon	...	„ „ „	1·30	„	„
Manganese	...	„ „ „	1·00	„	„
Chromium	...	„ „ „	0·50	„	„
Zinc	... ...	„ „ „	0·03	„	„

2. **Sections.**—May be formed by extrusion, rolling or by drawing.

3. **Number of Tensile Tests.—Plates.** Plates from the same cast shall be grouped in thickness for testing as follows :—

(*a*) 1·00 inch and over in thickness.
(*b*) ·75 inch and less than 1·00 inch.
(*c*) ·50 inch and less than ·75 inch.
(*d*) ·18 inch and less than ·50 inch.

One tensile test is to be taken from each group.

4. **Number of Tensile Tests.—Sections.**—(*a*) Sections from the same cast of non heat-treatable material shall be grouped in weight as follows :—

(1) Less than one pound per foot.
(2) Between one pound and nine pounds per foot, inclusive.
(3) More than nine pounds per foot.

One tensile test is to be taken from each group.

(*b*) For sections from the same cast of heat-treatable alloy, the groups will be the heat-treatment batches as defined in Section 1, clause 8. One tensile test is to be taken from each group.

5. **Tensile Tests.—Plates and Sections.**—The 0·1 per cent proof stress is not to be less than 8 tons per square inch. The tensile breaking strength is not to be less than 17 tons per square inch, and the elongation, measured on a gauge length of 8 inches, is not to be less than 10 per cent.

6. **Occasional Attendance at Works.**—(*a*) Where the Society's Surveyor is not in constant attendance at the Works, the Manufacturer may, with the written authority of the Society, comply with all the prescribed requirements and furnish the Surveyor with a certificate to the effect that the Society's Rules for the testing of aluminium alloys for shipbuilding purposes have been complied with in the case of material submitted for approval. The Surveyor is then to examine the Works history sheets for the material submitted and, if these are in order, to take check tensile tests from the materials. If the material in a single cast is of uniform thickness, two tensile test pieces are to be selected; if of different thicknesses two tensile test pieces are to be selected from the range of thicknesses presented. The test pieces are to be selected by the Surveyor from the plates or sections themselves, and not from shearings previously detached from them, and, when marked by the Surveyor for testing, they are to be followed, as far as is practicable, through the different stages of preparation until the tests are completed.

If more than one cast is represented each cast is to be tested.

(*b*) Where the tests are unsatisfactory, the whole of the material from the cast is to be rejected and the Surveyor is to see that the Society's brand is satisfactorily defaced.

APPENDIX.

The following Establishments have complied with the Requirements for Quality and Testing of Aluminium Alloys for Shipbuilding Purposes as at 31st December, 1949.

Birmetals Ld., Quinton, Birmingham.
James Booth & Co., Ld., Birmingham.
British Aluminium Co., Ld., Falkirk.
British Aluminium Co., Ld., Milton, Staffs.
British Aluminium Co., Ld., Warrington.
High Duty Alloys Ld., Distington, nr. Workington.
I.C.I. Ld., Waunarlwydd, nr. Swansea.
E. & E. Kaye, Ld., Enfield, Middlesex.
Lavorazione Leghe Leggere, Ferrara and Marghera, (Venice).
N.V. Nederlandsche Aluminium Maats., Utrecht, Holland.
Northern Aluminium Co., Ld., Banbury.
Northern Aluminium Co., Ld., Newport, Mon.
S.A. Sidal, Societe de L'Aluminium, Duffel, Belgium.
A/B Svenska Metallverken, Finspong, Sweden.
T. I. Aluminium Ld., Tyseley, Birmingham.

71, Fenchurch Street, London, E.C.3.
11th December, 1947.

STEEL MANUFACTURERS
AND
PROVING ESTABLISHMENTS.

LLOYD'S REGISTER OF SHIPPING.

STEEL MANUFACTURERS.

The following firms having applied to have the steel produced by them tested by a Surveyor to this Society and their mode of procedure reported upon, their applications have been complied with and the Surveyors' reports found satisfactory by the Committee.

Firms in Great Britain and Ireland.

Allen, Edgar, & Co., Ld., Imperial Steel Works, Tinsley, Sheffield. (*Steel castings.*)

Alston Foundry Co., Ld., Nent Force Foundry Alston, Cumberland. (*Small steel castings.*)

Appleby-Frodingham Steel Co., Ld., Scunthorpe, Lincs.,

Appleby Works. (*Steel plates and blooms.*)

Frodingham Works. (*Sections, bars and blooms.*)

Atlas (The) Steel Foundry and Engineering Co., Ld., Armadale, West Lothian. (*Steel castings.*)

Babcock & Wilcox, Ld., Renfrew. (*Small steel castings.*)

Baird, Archibald, & Son, Ld., Hamilton, near Glasgow. (*Steel castings.*)

Bairds & Scottish Steel, Ld., Coatbridge, Lanarkshire.

Northburn Works. (*Steel ingots and billets, sections and bars.*)

Waverley Works. (*Sections and bars.*)

Victoria Works. (*Sections and bars.*)

Woodside Works. (*Sheets and strips.*)

Coats Works. (*Sections and bars.*)

Rochsolloch Works. (*Sections and bars.*)

Baker Bessemer, J., Ld., Kilnhurst Steel Works, near Rotherham. (*Ingots and forgings.*)

Beardmore, William, & Co., Ld., Parkhead, Glasgow.

Blackett, Hutton & Co., Cleveland Steel and Iron Works, Guisborough, Yorkshire. (*Steel castings.*)

Blaenavon Co., Ld., near Pontypool, Mon. (*Steel ingots.*)

Bond's Foundry Co., Tow Law, Co. Durham. (*Small steel castings.*)

Bonnington Castings, Ld., Leith. (*Small steel castings.*)

Braby, Fredk., & Co., Ld., Eclipse Iron and Galvanizing Works, Glasgow. (*Rolling Mills for plates up to $\frac{1}{4}$ in. in thickness.*)

British Rolling Mills, Ld., Brymill Works, Tipton, Staffs. (*Cold drawn bright steel bars.*)

Brockhouse Castings, Ld., Wednesfield, Wolverhampton. (*Small steel castings.*)

Brown, Bayley's Steel Works, Ld., Sheffield. (*Steel ingots, forgings, and bars.*)

Brown, The David, Foundries Co., Penistone, Yorks. (*Steel castings.*)

Brown, Lenox & Co., Ld., Pontypridd. (*Steel castings.*)

Cargo Fleet Iron Co., Ld. (*See* South Durham Steel & Iron Co., Ld.)

Carntyne Steel Castings Co., Ld., Moorpark, Renfrew. (*Steel castings.*)

Catton & Co., Ld., Yorkshire Steel Foundry, Hunslet, Leeds. (*Steel castings.*)

Clyde Alloy Steel Co., Ld., Craigneuk Works, Flemington, Motherwell. (*Steel castings.*)

Coghlan Forge & Rolling Mills, Ld., and Coghlan Bright Steel, Ld., Hunslet Forge, Leeds. (*Rolling Mills for bars; forgings.*)

Coltness Iron Co., Ld., Newmains, Lanarkshire. (*Steel castings.*)

Colvilles Ld.,

Dalzell Steel and Iron Works, Motherwell, Lanarkshire.

Clydebridge Steel Works, Cambuslang, near Glasgow.

Glengarnock Iron and Steel Works, Glengarnock, Ayrshire. (*Sections and bars.*)

Consett Iron Co., Ld., Blackhill, Durham.

Consett Iron Co., Ld., (Jarrow Mill), Blackett Street, Jarrow-on-Tyne. (*Rolling Mills for sections and rounds.*)

Crofts (Engineers), Ld., Thornbury, Bradford. (*Steel castings.*)

Cruikshank & Co., Ld., Denny, Stirlingshire. (*Small steel castings.*)

Darlington Forge Co., Ld., Darlington. (*Steel castings and forgings.*)

Darlington & Simpson, Rolling Mills Ld., Darlington. (*Rolling Mills for small sections and bars.*)

Davy & United Roll Foundry, Ld., Empire Works, Haverton Hill, Billingham, Co. Durham. (*Steel castings.*)

Dorman, Long & Co., Ld. (Incorporating Bolckow, Vaughan & Co., Ld.),

Britannia Steel Works, Middlesbrough.

Cleveland Iron and Steel Works, South Bank-on-Tees.

Redcar Iron and Steel Works, Redcar.

English Steel Corporation, Ld.,

North Street Works, Openshaw, Manchester. (*Steel castings, forgings, bars and plates up to* ½ in. *in thickness.*)

Vickers Works, Sheffield. (*Steel ingots, blooms, bars, forgings and castings.*)

Cammell Laird's Grimesthorpe Works, Sheffield. (*Steel ingots, forgings and castings.*)

Etna Iron and Steel Co., Ld., Motherwell, Lanarkshire. (*Rolling Mills for sections and bars.*)

Firth, Thomas, & John Brown, Ld.,

Atlas Works, Sheffield. (*Ingots, forgings, rolled bars and billets.*)

Norfolk Works, Sheffield. (*Steel castings and rolled strips.*)

Scunthorpe Works, Scunthorpe, Lincs. (*Steel castings.*)

Firth Vickers Stainless Steels, Ld., Sheffield. (*Rolling Mills for plates, bars and sections; also steel castings.*)

Fox (Samuel) & Co., Ld., Stocksbridge Works, near Sheffield. (*Steel ingots.*)

Glanmor Foundry Co., Llanelly. (*Steel castings.*)

Guest, Keen & Nettlefolds, Ld.,

Castle Works, Rolling Mills, Cardiff. (*Rolling Mills for bars and strips.*)

Cwmbran Works, near Newport, Mon. (*Rolling Mills for flat, round and angle bars.*)

Guest Keen Baldwins Iron & Steel Co., Ld., East Moors Steel Works, Cardiff. (*Steel ingots, blooms and billets; sections and bars.*)

Hadfields, Ld., East Hecla Works, Sheffield. (*Steel ingots, blooms, billets, forgings, bars, special sections and castings.*)

Halesowen (The) Steel Co., Ld., Halesowen, near Birmingham. (*Cold drawn bright steel bars.*)

Hamilton, A., & Sons, Ld., Victoria Foundry, East Moors, Cardiff. (*Small steel castings.*)

Head, Wrightson & Co., Ld., Thornaby-on-Tees. (*Steel castings.*)

Hopkinsons, Ld., Britannia Works, Huddersfield, Yorkshire. (*Steel castings.*)

Hyde (Robert) & Son, Ld., North Stafford Steel Works, Stoke-on-Trent. (*Small steel castings.*) Also Works at Chesterfield

Industrial Steels, Ld., Stevenson Road, Sheffield. (*Steel ingots, blooms, billets and bars.*)

Jackson, P. R., & Co., Ld., Salford, Manchester. (*Steel castings.*)

Jarrow Metal Industries, Ld., Western Road, Jarrow. (*Steel castings.*)

Jessop, W., & Sons, Ld., Brightside Works, Sheffield. (*Steel ingots, blooms, bars, forgings and castings.*)

Jopling, E., & Sons, Pallion, Sunderland. (*Steel castings.*)

Kirkstall Forge Ld., Leeds. (*Rolling Mills for bars, steel forgings and heavy drop forgings.*)

Kryn & Lahy (1928), Ld., Letchworth, Hertfordshire. (*Steel castings.*)

Lake & Elliot, Ld., Proprietors of the Braintree Castings Co., Braintree, Essex. (*Small steel castings.*)

Lanarkshire Steel Co., Ld., Motherwell, Lanarkshire.

Lancashire Steel Corporation, Ld., Irlam, Manchester. (*Billets, bars, sections, and steel castings*)
Pearson & Knowles Works, Warrington, Lancs. (*Rolling Mills for sections and bars.*)
Lilleshall Co., Ld., St. George's, near Oakengates, Shropshire. (*Rolling Mills for sections and bars.*)
Lloyd, F. H., & Co., Ld., James Bridge, near Wednesbury, Staffordshire. (*Steel castings.*)
Lysaght, John, Ld., Scunthorpe, Lincs. (*Steel ingots, billets and slabs.*)
Martin, William, Sons & Co., Dundyvar Iron & Steel Works, Coatbridge, Lanarkshire. (*Rolling Mills for sections and bars.*)
Mills, Exors. of James, Ld., Bredbury Steel Works & Rolling Mills, near Stockport. (*Rolling Mills for steel bars.*)
Ministry of Supply, Barrow Works.
Ministry of Supply, Monk Bridge Factory, Leeds, 12. (*Rolled bars and forgings.*)
Monks, Hall & Co., Ld., Warrington. (*Rolling Mills for bars.*)
National Steel Foundry (1914), Ld. (The), Kirkland Works, Leven, Fifeshire. (*Steel castings.*)
North British (The) Steel Foundry, Ld., Balbardie Steel Works, Bathgate. (*Small steel castings.*)
Osborn, S., & Co., Clyde Steel & Iron Works, Sheffield. (*Steel castings.*)
Park Gate Iron & Steel Co., Ld., Rotherham, Yorkshire.
Parker Foundry (1929) Ld., "Tropenas" Steel Works, Derby. (*Small steel castings.*)
Partridge, Jones & John Paton, Ld., Pontymister Foundry, Risca, nr. Newport, Mon. (*Steel castings.*)
Patent Shaft & Axletree Co., Ld., Wednesbury, Staffordshire.
Raine & Co., Ld., Delta Iron & Steel Works, Derwenthaugh, Newcastle-on-Tyne. (*Rolling Mills for sections and bars.*)
Redheugh Iron & Steel Co. (1936), Ld., Teams, Gateshead-on-Tyne. (*Rolling Mills.*)
Renton & Fisher, Ld., Hopetoun Steel Works, Bathgate. (*Steel castings.*)
Robertson, Wm., Ld., Latchford, Warrington. (*Cold drawn bright steel bars.*)
Round Oak Steel Works, Ld., Brierley Hill, Staffordshire. (*Sections and bars.*)
Ryder Brothers, Ld., (Beehive Steel Foundry), Bolton. (*Small steel castings.*)
Shaw, W., & Co., Middlesbro'-on-Tees. (*Steel castings.*)
Shelton Iron, Steel & Coal Co., Ld., Stoke-on-Trent. (*Steel ingots, billets, bars and sections.*)
Skinningrove Iron Co., Ld., Skinningrove Iron Works, Saltburn-by-the-Sea. (*Sections and bars.*)
Smith & McLean, Ld., Mossend, and Gartcosh, Lanarkshire. (*Rolling Mills for plates up to* $\frac{5}{16}$ in. *in thickness.*)
South Durham Steel & Iron Co., Ld., Middlesbrough. *Works at* West Hartlepool and Cargo Fleet.
Springfield Steel Co., Ld., 1323, London Road, Glasgow. (*Steel castings.*)
Steel Company of Scotland, Ld., Newton, Glasgow; and Blochairn, Glasgow.
Steel Company of Wales, Ld.
Port Talbot Steel Works, Port Talbot, S. Wales.
Margam Steel Works, Port Talbot.
Steel, Peech & Tozer, Sheffield. (*Steel ingots, blooms, forgings, rivet and stay bars.*)
Stewarts & Lloyds, Ld., (Clydesdale Steel and Iron Works), Mossend, Lanarkshire. (*Steel ingots only.*)
Stewarts & Lloyds, Ld., Sun Foundry, Coatbridge, Lanarkshire. (*Steel castings.*)
Stewarts & Lloyds, Ld., Alfred Hickman Branch, Bilston, Staffordshire.
Stewarts & Lloyds, Ld., Landore, S. Wales. (*Seamless steel tubes for all purposes.*)
Stockton Steel Foundry Co., Ld., Stockton-on-Tees. (*Steel castings.*)
Summerson, Thomas, & Sons, Ld., Darlington. (*Small steel castings.*)
Taylor Bros. & Co., Ld., Trafford Park Steel Works, Manchester. (*Steel ingots.*)
Thomas (Richard) & Baldwins, Ld., Redbourn Works, Scunthorpe, Lincolnshire. (*Steel ingots and billets.*)
United Strip and Bar Mills, The Ickles, Sheffield. (*Rolling Mills for bars.*)
Vickers-Armstrongs, Ld.
Barrow-in-Furness. (*Steel castings and forgings.*)
Elswick Works, Elswick, Northumberland. (*Steel castings.*)
Washington Steel Foundries, Ld., Washington Station S.O., Co. Durham. (*Steel castings.*)

West Lothian Steel Foundry Co., Ld., Harthill Works, Armadale, West Lothian. (*Small steel castings.*)

Whitehead Iron & Steel Co., Ld., Courtybella Works, Newport, Mon. (*Rolling Mills for steel strips, bars and sections.*)

Whitehead Thomas Bar and Strip Co., Ld., Redbourn Works, Scunthorpe, Lincs. (*Rolling Mills for steel bars and strips.*)

Williams (John), & Co. (Wishaw), 1922, Ld., Excelsior Iron & Steel Works, Craigneuk, Motherwell. (*Rolling Mills for plates up to* $\frac{5}{16}$ in. *in thickness.*)

Wolsingham Steel Co., Ld., Wolsingham, Co. Durham. (*Steel castings and forgings.*)

FIRMS IN COUNTRIES OTHER THAN GREAT BRITAIN AND IRELAND.

ALPHABETICALLY ARRANGED.

In Germany and Japan, and in countries which were occupied by forces from these nations, information regarding the steel works is still incomplete and names of the works have only been included if inspection has been carried out since the war.

In the following list the name of each works is followed by the place of residence of the Surveyor giving attendance thereat.

A.I. Iron & Steel Foundry, Ld., Vancouver. (*Small steel castings.*) (VANCOUVER.)

A/S Drammens Jernstoberi & Mek-Verksted, Drammen, Norway. (*Small steel castings.*) (OSLO.)

A/S Strömmens Verksted, near Oslo, Norway. (*Steel castings.*) (OSLO.)

A.S.S.A. Acciaierie di Susa Società Anonima, Torino, Italy. *Head Office* in Turin. *Works* at Susa. (*Steel castings.*) (GENOA.)

Acciaieria e Ferriera del Caleotto Società Anonima, Lecco Italy. (*Steel ingots, bars, small sections and small forgings.*) (GENOA.)

Acciaieria e Tubificio di Brescia, Società Anonima, Brescia, Italy. (*Steel ingots, sections and bars, steel castings, weldless drawn or water gas welded tubular material.*) (GENOA.)

Acciaierie e Ferriere Lombarde Falck. *Head Office:* Milan. *Works* at Milan. (*Weldless rolled or drawn steel tubes.*) (GENOA.)

'Unione' *Works* at Sesto S. Giovanni. (*Steel ingots, sections, bars, forgings, also steel castings.*) (GENOA.)

'Concordia' *Works* at Sesto S. Giovanni. (*Rolling Mills for steel plates.*) (GENOA.)

Acciaierie Elettriche Pio Faggian, La Spezia, Italy. (*Small steel castings.*) (GENOA.)

Acciaierie Valbruna di Ernesto Gresele, Vicenza, Italy. (*Steel castings, bars and sections and forgings.*) (TRIESTE.)

Aceros de Llodio, Ltda., Llodio, near Bilbao, Spain. (*Small steel castings, ingots and forgings.*) (BILBAO.)

Aciéries de Haine St. Pierre et Lesquin, Société Anonyme. Haine St. Pierre, Belgium. (*Steel castings.*) (ANTWERP.)

Aciéries et Ateliers de Grosse Forge, Maurice Dembiermont & Cie., Hautmont (Nord), France. (*Steel forgings.*) (VALENCIENNES.)

Aciéries & Minières de la Sambre.

Works at Monceau-sur-Sambre, Belgium. (*Rolling Mills for bars.*) (ANTWERP.)

Works at Nimy, Belgium. (*Rolling Mills for bars.*) (ANTWERP.)

Acieries Reunies de Burbach-eich-Dudelange. (ARBED.)

Division de Dommeldange, Dommeldange, Luxembourg. (*Steel ingots, forgings and castings.*) (ANTWERP.)

Division de Dudelange, Greisendahl, Luxembourg. (*Rolling mills for plates up to 8mm. in thickness.*) (ANTWERP.)

Division de Belval, Esch-sur-Allzette, Luxembourg. (*Steel ingots, blooms, billets, bars and angle bars.*) (ANTWERP.)

Division d'Esch, Esch-sur-Allzette, Luxembourg. (*Rolling Mills for bars and sections.*) (ANTWERP.)

Aktiebolag Svenska Jarnvagsverkstaderna, Linköping, Sweden. (*Steel castings.*) (STOCKHOLM.)

Aktiebolaget Abjörn Anderson, Svedala, near Malmö, Sweden. (*Steel castings.*) (MALMÖ.)

Aktiebolaget Bofors, Bofors, Sweden. (*Melting Furnaces and Foundry.*) (GOTHENBURG.)

Aktiebolaget Kanthal, Hallstahammar, Sweden. (*Steel castings and rivet bars.*) (STOCKHOLM.)

Aktiebolaget Motala Verkstad, Motala Verkstad, Sweden. (*Melting Furnaces, Rolling Mills and Forge; also steel castings.*) (GOTHENBURG.)

Aktiebolaget Nordiska Armaturfabrikerna, Linköping, Sweden. (*Steel castings.*) (STOCKHOLM.)

Alan Wood Steel Company, Conshohocken and Ivy Rock Pa., U.S.A. (*Blooms, billets and thin plates.*) (PHILADELPHIA.)

Algoma Steel Corporation, Ld., Sault St. Marie, Ontario, Canada. (*Steel billets, bars and angles.*) (TORONTO.)

Altos Hornos de Vizcaya. S.A., Fabrica de Sagunto Sagunto, Spain. (*Steel ingots, bars and sections.*) (BARCELONA.)

Amagasaki Iron & Steel Manufacturing Co., Ld., Kure Works, Kure, Japan. (*Ingots and steel castings.*) (KOBE.)

American Locomotive Co., Railway Steel Spring Division Latrobe, Pa., U.S.A. (*Steel ingots.*) (PITTSBURGH, PA.),

American Rolling Mill Co., Middletown, O., U.S.A. (*Steel castings and forgings.*) (CLEVELAND, O.)

American Steel Foundries, Newark, N.J., U.S.A. (*Steel castings.*) (NEW YORK.)

Ansaldo Società Anonima, Stabilimento Fossati, Genoa-Sestri, Italy. (*Steel forgings.*) (GENOA.)

Atlantic Steel Castings Co., Chester, Pa., U.S.A. (*Steel castings.*) (PHILADELPHIA.)

Atlas Steels, Ld., Welland, Ontario, Canada. (*Steel ingots and bars.*) (TORONTO.)

Australian Iron & Steel, Ld., Port Kembla, N.S.W. (*Steel plates, bars, sections and forgings.*) (SYDNEY, N.S.W.)

Avesta Jernverks Aktiebolag, Avesta, Sweden. (*Steel plates, sections and castings; also high pressure air receivers.*) (STOCKHOLM.)

Bengal Steel Corporation, Burnpur, India. (*Sections and angles.*) (CALCUTTA.)

Bethlehem Pacific Coast Steel Corporation, Los Angeles 54, Cal., U.S.A. (*Round bars.*) (LOS ANGELES.)

Seattle, Wash., U.S.A. (*Sections and bars.*) (SEATTLE.)

South San Francisco, Cal., U.S.A. (*Steel ingots, small sections and bars.*) (SAN FRANCISCO.)

Bethlehem Steel Co.,

Bethlehem, Pa., U.S.A. (*Steel ingots, forgings, bars and sections.*) (PHILADELPHIA.)

Buffalo, N.Y., U.S.A. (CLEVELAND, O.)

Cambria Works, Johnstown, Pa., U.S.A. (PITTSBURGH.)
Lebanon, Pa., U.S.A. (*Rolling Mills for bars.*) (PHILADELPHIA.)
Sparrows Point, Md., U.S.A. (BALTIMORE.)
Steelton, Pa., U.S.A. (*Steel forgings and castings.*) (PHILADELPHIA.)

Birdsboro Steel Foundry & Machine Co., Birdsboro, Pa., U.S.A. (*Steel castings.*) (PHILADELPHIA.)

Björneborgs Jernverks Aktiebolag, Björneborg, Sweden. (*Melting Furnaces and Forge.*) (GOTHENBURG.)

Bradford, Kendall, Ld., Alexandria, Sydney, N.S.W. (*Steel castings.*) (SYDNEY, N.S.W.)

Broken Hill Proprietary Co., Ld., Iron and Steel Works, Newcastle, N.S.W. (*Steel plates, bars, sections and castings.*) (NEWCASTLE, N.S.W.)

Burmeister & Wain's Maskin-og Skibsbyggeri, Aktieselskabet, Copenhagen, Denmark. (*Steel ingots, forgings and castings.*) (COPENHAGEN.)

Canada Foundries & Forgings, Ld., Welland, Ontario. (*Steel forgings.*) (TORONTO.)

Canadian Car & Foundry, Steel Foundry Division, Longue Pointe, Montreal. (*Steel castings.*) (MONTREAL.)

Canadian Sumner Iron Works Ld., Vancouver, B.C. (*Small steel castings.*) (VANCOUVER.)

Canadian Tube & Steel Products, Ld., 5765, Hamilton Street, Montreal, P.Q. (*Steel angles, bars and rivets.*) (MONTREAL.)

Canadian Unitcast-Steel, Ld., Sherbrooke, Quebec, Canada. (*Steel castings.*) (MONTREAL).

Carnegie-Illinois Steel Corporation, Chicago, Ill., U.S.A. (CHICAGO, ILL.)

Carnegie-Illinois Steel Corporation, Pittsburgh, Pa., U.S.A. (PITTSBURGH.)

Central Iron & Steel Co., Harrisburg, Pa., U.S.A. (*Rolling Mills.*) (PHILADELPHIA.)

Centralny Zarzad Premyszlu Hutniciego, Katowice, Poland,
Huta Baildon, Katowice, GS/I, Poland. (*Steel ingots, blooms, billets, bars and sections.*) (KATOWICE.)
Huta Bankowa, Dabrowa Gornicza, G/S, Poland. (*Steel ingots, sections, bars, castings and forgings.*) (KATOWICE.)
Huta Batory, Katowice, Poland. (*Steel ingots, plates, forgings, weldless rolled tubes and hollow pillars.*) (KATOWICE.)
Huta Florian, Swietochlowice, Poland. (*Rolled bars and sections.*) (KATOWICE.)
Huta Kosciuszko, Chorzow, Poland. (*Rolled steel sections.*) (KATOWICE.)
Huta Laura, Siemianowice, Poland. (*Seamless steel tubes.*) (KATOWICE.)
Huta Ostrowiec, Ostrowiec, Poland. (*Rolled bars and sections.*) (KATOWICE.)
Huta Pokoj, Nowy Bytom, Poland. (KATOWICE.)
Huta Stalowa Wola, Katowice, Poland. (*Plates and forgings.*) (KATOWICE.)
Huta Zawiercze, Zawiercze, Poland. (*Rolled bars and sections.*) (KATOWICE.)

Ceskomoravska-Kolben-Danek Steel Works (National Corporation), Prague, Czechoslovakia. (PILSEN.)

Christiania Spigerverk, Oslo, Norway. (*Steel ingots and bars, also rivet bars.*) (OSLO.)

Colorado Fuel & Iron Corporation, Minnequa Works, Pueblo, Colorado. (*Steel ingots, bars and small sections.*) (CHICAGO.)

Columbia Steel Company, Torrance, Cal., U.S.A. (*Round bars, sections and sheets, also steel castings.*) (LOS ANGELES.)

Commonwealth Steel Co., Ld., Waratah, Newcastle, N.S.W. (*Steel castings and forgings.*) (NEWCASTLE, N.S.W.)

Compagnie de Fives-Lille Société Anonyme, Fives-Lille (NORD), France. (*Steel ingots, castings and forgings*). (VALENCIENNES.)

Compagnie des Forges et Aciéries de la Marine et d'Homécourt, Homécourt (Meurthe et Moselle), France. (*Ingots, blooms, billets and plates.*) (VALENCIENNES.)

Compagnie des Forges et Aciéries de la Marine et d'Homécourt, St. Chamond (Loire), France. (ST. ETIENNE.)

Compagnie Generale des Aciers, Société Anonyme, Thy-le-Chateau, Belgium. (*Steel castings.*) (ANTWERP.)

Companhia União Fabril, Lisbon, Portugal. (*Steel castings.*) (LISBON.)

Companhia União Fabril, Barreiro, Portugal. (*Steel castings.*) (LISBON.)

Compañia Anonima Basconia, Bilbao, Spain. (BILBAO.)

Compañia Auxiliar de Ferrocarriles, Beasain, Guipuzcoa, Spain. (*Small steel castings and forgings.*) (BILBAO.)

Compañia Euskalduna, Talleres de Elorrietta, Bilbao, Spain. (*Steel castings.*) (BILBAO.)

Compania Siderurgica Nacional Steel Works, Volta Redonda, Est. do Rio de Janeiro, Brazil. (*Steel plates and sections.*) (RIO DE JANEIRO.)

Crucible Steel Castings Co., Lansdowne, Pa., U.S.A. (*Steel castings.*) (PHILADELPHIA.)

Crucible Steel Company of America, Pittsburgh Crucible Division, Midland, Pa., U.S.A. (PITTSBURGH.)

Danske, (Det), Staalvalsevaerk A/S, Frederiksvaerk, Denmark. (*Plates, sections and bars.*) (COPENHAGEN.)

Degerfors Järnverks Aktiebolag, Degerfors, Sweden. (*Melting Furnaces and Rolling Mills.*) (GOTHENBURG.)

Dikkers, G., & Co., N.V. Hengelo, Holland. (*Small steel castings.*) (AMSTERDAM.)

Dodge Steel Company, Tacony, Philadelphia, Pa., U.S.A. (*Small steel castings.*) (PHILADELPHIA.)

Dominion Foundries & Steel Ld., Hamilton, Ontario, (*Steel ingots, plates and castings.*) (TORONTO.)

Dominion Steel & Coal Corporation, Ld., Sydney, Nova Scotia. (*Steel ingots, billets, and sections.*) (HALIFAX, N.S.)

Dortmund-Horder Hüttenverein, Dortmund, Germany. (*Bars and sections*) (DORTMUND.)

Dunswart Iron & Steel Works, Ld., Benoni, South Africa. (*Steel castings, ingots, billets and small sections.*) (DURBAN.)

East Japan Heavy Industries Ld., Yokohama Shipyard & Engine Works, Yokohama, Japan. (*Steel ingots, blooms, small forgings and castings.*) (YOKOHAMA).

Enterprise Engine & Foundry Co., South City, Cal., U.S.A. (*Steel castings.*) (SAN FRANCISCO.)

Erie Forge Co., Erie, Pa., U.S.A. (*Steel ingots, forgings and castings.*) (CLEVELAND, O.)

Fabrica Italiana Tubi, Società Anonima, Sestri-Levante, Italy. (*Steel ingots, billets and weldless rolled and drawn steel tubes*). (GENOA.)

Fabrica Nacional de Trubia, Trubia Asturias, Spain. (*Steel castings and forgings.*) (BILBAO.)

Fagersta Bruks Aktiebolag, Fagersta, Sweden (Brukskoncernen.)

Works at Fagersta. (*Steel blooms and billets, forgings and rolled bars.*)

Works at Forsbacka. (*Steel blooms, billets, tubes and forged and rolled bars.*) (STOCKHOLM.)

Works at Horndal. (*Steel bars and angles.*)

Works at Osterbybruk. (*Steel castings.*)

Falk Corporation, Milwaukee, Wis., U.S.A. (*Steel castings.*) (CLEVELAND, O.)

Finkl (A.) & Sons Company, Chicago, Ill., U.S.A. (*Steel forgings.*) (CHICAGO, ILL.)

First Brno & Kralovo Pole Engineering Works (National Corporation), Brno, Czechoslovakia. (*Steel castings.*) (PILSEN.)

Fonderie Acciaierie Milanesi Vanzetti, Milan. (*Steel castings*) (GENOA.)

Fonderie Elettriche Pracchi, Milan. Italy. (*Small steel castings.*) (GENOA.)

Fonderies, Forges et Aciéries de St. Etienne, St. Etienne, France. (ST. ETIENNE.)

Forges et Acieries de Volklingen, Gestion Francaise des Ancinnes Rochling, Volklingen (Sarre). (*Ingots, billets, bars and forgings, including alloy steels.*) (DUSSELDORF.)

Forges et Ateliers de Constructions Electriques de Jeumont. Jeumont (Nord), France. (*Steel castings.*) (VALENCIENNES.)

Fratelli Bruzzo-Ferriera di Bolzaneto, Genova-Bolzaneto, Italy. (*Steel plates, sections and bars.*) (GENOA.)

Fundiciones Escorsa S.A., Pi y Margall, 2- Hospitalet de Llobregat, Barcelona, Spain. (*Steel castings.*) (BARCELONA.)

Fuso Metal Industries, Ld.

Steel Tube Works, Amagasaki, Japan. (*Ingots, small bars and sections, weldless steel tubes.*) (KOBE.)

Steel Works, Osaka, Japan. (*Steel castings and forgings.*) (KOBE.)

General Metals Corporation, Oakland, Cal., U.S.A. (*Steel castings.*) (SAN FRANCISCO.)

General Steel Castings Corporation, Eddystone, Pa., U.S.A. (*Steel castings.*) (PHILADELPHIA.)

Geneva Steel Company (United States Steel Corp. Subsidiary), Geneva, Utah, U.S.A. (*Steel plates.*) (LOS ANGELES.)

Georgs-Marienhutte A.G., Osnabruck, Germany. (*Steel ingots and bars.*) (DUSSELDORF.)

Giovanni Villa, Società Anonima, Officine Meccaniche - Fucinati - Stampati, Milan, Italy. (*Steel forgings.*) (GENOA.)

Gussstahlwerk Oberkassel Aktiengesellschaft, Dusseldorf-Oberkassel, Germany. (*Steel castings.*) (DUSSELDORF.)

Gutehoffnungshütte Oberhausen A.G., Werk Sterkrade, Sterkrade, Germany. (*Steel forgings.*) (DUSSELDORF.)

Hadfields Steel Works, Ld., Alexandria, Sydney, N.S.W. (*Steel castings.*) (SYDNEY, N.S.W.)

Hakodate Dock Co., Ld., Hakodate Shipyard, Hakodate, Japan. (*Small steel forgings and castings.*) (YOKOHAMA.)

Hallstahammars Aktiebolag, Hallstahammar, Sweden. (*Steel bars.*) (STOCKHOLM.)

Harima Shipbuilding Works Ld., Harima, Japan. (*Steel castings and forgings.*) (KOBE.)

Hellefors Bruks Aktiebolag, Hällefors, Sweden. (*Steel bars.*) (GOTHENBURG.)

Helsingors Skibsvaerft-og Maskinbyggeri A/S, Aktieselskabet, Elsinore, Denmark. (*Steel ingots, forgings and castings.*) (COPENHAGEN.)

Hüttenwerk Haspe A.G., Hagen-Haspe (Dortmund), Germany. (*Steel ingots, plates, bars and sections.*) (DORTMUND.)

Hüttenwerk Huckingen A.G., Duisburg, Germany. (*Steel ingots, plates, sections and bars.*) (DUSSELDORF.)

Hüttenwerk Oberhausen A.G., Oberhausen, Germany. (*Steel ingots, plates, sections and bars.*) (DUSSELDORF.)

Hüttenwerke Hoerde A.G., Dortmund Hoerde, Germany. (*Steel castings, ingots, plates, sections, bars and forgings.*) (DORTMUND.)

Hüttenwerk Rheinhausen A.G., Rheinhausen, Germany. (*Bars and sections only.*) (DUSSELDORF.)

Ilva Alti Forni e Acciaierie D'Italia : *Head Office*, Genoa,

Stabilimento di Bagnoli. (*Steel ingots, sections and bars.*) (NAPLES.)

Stabilimento di Genova-Bolzaneto. (*Sections and bars.*) (GENOA.)

Stabilimento di Genova-Voltri. (*Rivets.*) (GENOA.)

Stabilimento di Lovere. (*Sections, bars, castings and forgings.*) (GENOA.)

Stabilimento di Marghera. (*Steel castings, also rolling mills for small steel sections and bars.*) (TRIESTE.)

Stabilimento di Novi Ligure. (*Sections, bars and plates.*) (GENOA.)

Stabilimento di Porto Vecchio de Piombino. (*Steel ingots blooms, sections and bars.*) (GENOA.)

Stabilimento di Savona. (*Sections, bars and plates.*) (GENOA.)

Stabilimento di Servola (*Steel ingots, billets and plates.*) (TRIESTE.)

Stabilimento di Torre Annunziata, Centrale. (*Steel ingots, sections and bars.*) (NAPLES.)

Industrial Steels, Ld., Lidcombe, Sydney, N.S.W. (*Steel castings.*) (SYDNEY, N.S.W.)

Inland Steel Co., Indiana Harbor, Ind., U.S.A. (*Steel ingots, blooms, billets and slabs.*) (CHICAGO.)

Iscor Vanderbyl Works, Plate Division, Houlkop, nr. Vereeniging, S. Africa. (*Rolling Mills for plates.*) (DURBAN.)

Ishikawajima Heavy Industries Co., Ld., Tokyo, Japan. (*Steel castings and forgings.*) (YOKOHAMA.)

Japan Iron & Steel Co., Ld., Kamaishi, Japan. (*Sections and bars.*) (YOKOHAMA.)

Japan Iron & Steel Co., Ld., Yawata, Japan. (*Steel plates, sections, steel ingots and forgings*). (KOBE.)

Japan Steel Works Ld., Muroran, Japan. (*Steel ingots, forgings and castings.*) (YOKOHAMA.)

Jones & Laughlin Steel Corporation, Pittsburgh, Pa., U.S.A. (PITTSBURGH.)

Kaiser Company, Inc., Iron & Steel Division, Fontana, Cal. U.S.A. (*Steel ingots and plates.*) (LOS ANGELES.)

Kanto Special Steel Works, Ld., Yokohama, Japan. (*Steel forgings.*) (YOKOHAMA.)

Kawasaki Heavy Industries, Ld.

Fukai Plant, Kobe. (*Steel plates.*) (KOBE.)

Hyogo Plant, Kobe. (*Steel castings and forgings.*) (KOBE.)

Kobe Steel Works, Ld., Kobe, Japan. (*Steel castings and forgings.*) (KOBE.)

Kockums Jernverk, Kallinge, Sweden. (*Steel castings.*) (MALMO.)

Kohlswa Jernverks Aktiebolag. (*Melting Furnaces, Foundry Forge and Rolling Mills for bars and small sections* at Kolsva, Sweden.) (STOCKHOLM.)

Koninklyke Nederlandsche Hoogovens & Staalfabrieken N.V. (Royal Netherlands Blast-furnaces & Steel Works Ld.), Ymuiden, Holland. (*Plates and sections.*) (AMSTERDAM.)

La Maquinista Terrestre y Maritima, S.A., Barcelona. (*Steel castings and forgings.*) (BARCELONA.)

Lebanon Steel Foundry, Lebanon, Pa., U.S.A. (*Small steel castings.*) (PHILADELPHIA.)

Los Angeles Steel Casting Co., Los Angeles, Cal., U.S.A. (*Steel castings.*) (LOS ANGELES.)

Lukens Steel Company, Coatesville, Pa., U.S.A. (PHILADELPHIA.)

Luzuriaga, Victorio, S.L., Pasajes, Guipuzcoa, Spain. (*Steel castings.*) (BILBAO.)

Lynn Macleod Metallurgy Ld., Thetford Mines, P.Q. Canada. (*Steel castings.*) (MONTREAL.)

Machine Fabriek Yzer-Staal & Metaal Gieterij (v/h Bakker & Co.), Ridderkerk. (*Steel castings.*) (ROTTERDAM.)

Manfred Weiss Steel & Metalworks National Enterprise, Budapest-Csepel, Hungary. (*Steel tubes.*) (BUDAPEST.)

Manitoba Rolling Mill Co., Ld., Winnipeg, Manitoba, Canada. (*Steel billets, bars and sections.*) (MONTREAL.)

Manitoba Rolling Mill Co., Ld., Selkirk, Manitoba, Canada. (*Steel castings.*) (MONTREAL.)

Maritime Steel Foundries, Ld., New Glasgow, Nova Scotia. (*Small steel castings.*) (HALIFAX, N.S.)

Mason & Cox, Ld., Adelaide, S. Australia. (*Steel castings,*) (ADELAIDE.)

MAVAG Metallurgical Works, National Enterprise, Budapest-Diósgyör, Hungary. (*Steel castings, forgings, plates and sections.*) (BUDAPEST.)

Melbourne Iron & Steel Mills Pty., Ld., Brooklyn' Melbourne, Australia. (*Steel ingots.*) (MELBOURNE.)

Mesta Machine Co., West Homestead, Pa., U.S.A. (*Steel ingots, castings and forgings.*) (PITTSBURGH.)

Metallurgica Vittorio Cobianchi-Soc. Anon. Head Office in Milan: Steel Works at Omegna (NOVARA.) (*Steel castings.*) (GENOA.)

Midvale Company (The), Nicetown, Philadelphia, Pa., U.S.A. (*Steel forgings.*) (PHILADELPHIA.)

Mining & Iron Works Company, National Corporation, Iron Works, Trinec, Ostrava, Czechoslovakia. (*Steel bars and sections, steel castings.*) (PILSEN.)

Mitsubishi Steel Works Co., Ld., Nagasaki, Japan. (*Steel ingots, blooms, forgings and castings.*) (KOBE.)

Mitsui Shipbuilding & Engineering Co., Ld., Tamano, Japan. (*Steel forgings and castings.*) (KOBE.)

National Enameling & Stamping Co., Granite City, Ill., U.S.A. (CLEVELAND, O.)

National Malleable and Steel Castings Co., Sharon, Pa. (*Steel ingots and steel castings.*) (CLEVELAND.)

Navalmeccanica S/A, Officine Meccaniche e Fonderie, Naples, Italy. (*Steel castings.*) (NAPLES.)

Nederlandsche Staalfabrieken (v/h J. M. de Muinck Keizer), Utrecht, Holland. (*Steel ingots, blooms, billets and castings; also steel rivet bars.*) (ROTTERDAM.)

Newport News Shipbuilding & Dry Dock Co., Newport News, Va., U.S.A. (*Steel castings and forgings.*) (NEWPORT NEWS.)

Nippon Soda Co., Ld., Oshima Steel Works, Tokyo, Japan. (*Steel castings and small forgings.*) (YOKOHAMA.)

Nippon Steel Foundry Ld., Osaka, Japan (*Steel castings.*) (KOBE.)

Nippon Steel Tube Co., Ld.

Kawasaki Iron & Steel Works, Kawasaki. Japan. (*Steel tubes, bars & sections.*) (YOKOHAMA.)

Tsurumi Iron & Steel Works, Tsurumi, Yokohama, Japan. (*Steel plates.*) (YOKOHAMA.)

Oesterreichisch-Alpine Montangesellschaft, Vienna.

Works at Donawitz, Styria. (*Plates and sections.*) (VIENNA.)

Works at Kindberg, Styria. (*Rolling Mills for small sections and bars.*) (VIENNA.)

Olympic Steel Works, Seattle, Wash., U.S.A. (*Steel castings.*) (SEATTLE.)

Osaka Chain & Machinery Manufacturing Co., Ld., Kaizurka Works, Osaka, Japan. (*Small steel castings.*) (KOBE.)

Pacific Car & Foundry Co., Renton, Wash., U.S.A. (*Steel castings.*) (SEATTLE.)

Pacific States Steel Corporation, Niles, California, U.S.A. (*Steel ingots, sections and bars.*) (SAN FRANCISCO.)

Pacific Steel Castings Co., Berkeley, Cal., U.S.A. (*Steel castings.*) (SAN FRANCISCO.)

Penn Steel Castings Corporation, Chester, Pa., U.S.A. (*Steel castings.*) (PHILADELPHIA.)

Pennsylvania Electric Steel Casting Co., Hamburg, Pa., U.S.A. (*Small steel castings.*) (PHILADELPHIA.)

Pennsylvania Forge Corporation, Tacony, Philadelphia, Pa., U.S.A. (*Steel forgings.*) (PHILADELPHIA.)

Phœnix-Iron Co., Phœnixville, Pa., U.S.A. (*Sections and bars.*) (PHILADELPHIA.)

Pittsburgh Steel Foundry Corporation, Glassport, Pa., U.S.A (*Castings.*) (PITTSBURGH.)

Ramnas Bruks Aktiebolag, Ramnas, Sweden. (*Rolling Mills. for bars.*) (STOCKHOLM.)

Raufoss Ammunisjonsfabrikker, Raufoss, Norway. (*Steel castings.*) (OSLO.)

"Reggiane" Officine Meccaniche Italiane S.p.A.-Reggio Emilia, Italy. (*Steel forgings.*) (GENOA.)

Reliance Foundry Co., Ld., Vancouver, B.C., Canada. (*Steel castings.*) (VANCOUVER.)

Republic Steel Corporation, Cleveland, O., U.S.A.

Alabama City, Ala., U.S.A. (MOBILE, ALA.)

Buffalo Plant, Buffalo, N.Y., U.S.A. (CLEVELAND, O.)

Central Alloy District, Massillon Plant, Massillon, O., U.S.A. (CLEVELAND, O.)

Chicago Plant, Chicago, Ill., U.S.A. (CHICAGO, ILL.) (*Steel Works* at 118th Street, Chicago, and *Rolling Mills* at East Chicago, Ind.) (*Steel angles and bars.*)

Cleveland District, Cleveland, O., U.S.A. (CLEVELAND, O.)

Corrigan McKinney Plant. (*Steel ingots, blooms and billets.*)

Upson Nut Plant. (*Round and square steel bars.*)

Youngstown Plant, Youngstown, O., U.S.A. (PITTSBURGH.)

Rheinische Röhrenwerke, Mulheim-Ruhr, Germany. (*Plates.*) (DUSSELDORF.)

Rimamurany Metallurgical Works, National Enterprise Budapest-Ozd, Hungary. (*Ingots, plates, bars and sections.*) (BUDAPEST.)

Ruhrstahl A.G., Henrichshütte, Hattingen-Ruhr, Germany. (*Steel ingots, plates, forgings and steel castings.*) (DORTMUND.)

Sandvikens Jernverks Aktiebolag, Sandviken, Sweden. (*Steel ingots, forgings and steel tubes.*) (STOCKHOLM.)

Sasebo Ship Industry Co., Ld., Sasebo, Japan. (*Steel castings and forgings.*) (KOBE.)

Schneider & Co., le Creusot, France. (ST. ETIENNE.)

SKF. Hofors Bruk, Hofors, Sweden. (*Steel billets, bars and forgings, and thick walled tubes.*) (STOCKHOLM.)

Skoda Works (National Corporation), Pilsen, Czechoslovakia. (*Steel forgings and castings, cast steel anchors.*) (PILSEN.)

Smedjebackens Valsverks Aktiebolaget, Smedjebacken, Sweden. (*Steel sections and castings.*) (STOCKHOLM.)

Sociedad Altos Hornos de Vizcaya, Bilbao, Spain. (BILBAO.)

Sociedad Anonima Echevarria, Bilbao, Spain. (*Small sections and bars.*) (BILBAO.)

Sociedad Industrial Asturiana, "Santa Barbara," Fabricas de Moreda y Gijon, Gijon, Spain. (*Rivet bars.*) (BILBAO.)

Sociedad Anonima Industrias Mecanicas, Barcelona, Spain. (*Steel castings.*) (BARCELONA.)

Sociedad Anonima Jose Maria Quijano, Forjas de Los Corrales de Buelna, Provincia de Santander, Spain. (*Steel bars.*) (BILBAO.)

Sociedad Anonima Talleres de Deusto, Deusto, Bilbao, Spain. (*Steel castings.*) (BILBAO.)

Sociedad Espanola de Construcciones Babcock & Wilcox Domicilio social: Calle Ercilla 1, Bilbao, Spain. Fabrica: Galindo-San Salvador Del Valle (Vizcaya), Spain. (*Steel castings, ingots and forgings.*) (BILBAO.)

Sociedad Española de Construccion Naval. *Works* at Reinosa, near Santander, Spain. (*Steel ingots, forgings, castings, plates, and sections.*) (BILBAO.)

Works at Sestao, near Bilbao, Spain. (*Small steel castings, ingots and forgings.*) (BILBAO.)

San Carlos Factory, San Fernando, Cadiz, Spain. (*Stee castings.*) (CADIZ.)

Sociedad Metalurgica Duro-Felguera, La Felguera, Asturias, Spain. (*Steel ingots, billets, castings, plates and sections.*) (BILBAO.)

Società Anonima Acciaierie Elettriche di Sesto San Giovanni, Sesto San Giovanni, Milan, Italy. (*Steel castings.*) (GENOA.)

Società Anonima Fonderie Acciaierie Liguri, Genova-Sampierdarena, Italy. (*Small steel castings.*) (GENOA.)

Società Anonima Fonderie Officine di Gorizia, Gorizia, Italy. (*Small steel castings.*) (TRIESTE.)

Società Anonima Nazionale "Cogne" (*Head Office*, Turin: *Works* at Aosta.) (*Steel ingots, forgings, plates, sections and bars.*) (GENOA.)

Società Italiana Acciaierie Cornigliano (*Head Office* and *Works* at Genova-Cornigliano.) (*Steel ingots, forgings, castings, plates and sections.*) (GENOA.)

Società Anonima Officine Fratelli Bertoli fu Rodolfo, Udine, Italy. (*Steel castings, forgings, bars and sections.*) (TRIESTE.)

Società Italiana Ernesto Breda Sesto S. Giovanni, Milan, Italy. (*Steel ingots, sections, forgings and steel castings.*) (GENOA.)

Società per Azioni Acciaierie di Bolzano, Bolzano, Italy. (*Steel ingots, billets, rolled bars, forgings and steel castings.*) (GENOA.)

Società per Azioni FIAT-Sezione Ferriere Piemontesi, Turin, Italy. (*Steel ingots, plates, sections, also seamless and welded tubes.*) (GENOA.)

Società per Azioni FIAT-Sezione Industrie Metallurgiche Acciaierie, Turin, Italy. (*Steel castings and forgings.*) (GENOA.)

Société Anonyme d'Escaut & Meuse, Anzin (Nord), France. (*Steel ingots and weldless rolled or drawn steel tubes.*) (VALENCIENNES.)

Société Anonyme de la Fabrique de Fer de Charleroi, Charleroi, Belgium. (*Steel ingots and plates.*) (ANTWERP.)

Société Anonyme de la Fabrique de Fer de Maubeuge, Louvroil (Nord), France. (*Steel ingots and plates.*) (VALENCIENNES.)

Société Anonyme des Aciéries ci-devant Georges Fischer, Schaffhouse, Switzerland. (*Steel castings.*) (WINTERTHUR.)

Société Anonyme des Aciéries de Haine-Saint-Pierre et Lesquin, Lesquin-lez-Lille (Nord), France. (*Steel castings.*) (VALENCIENNES.)

Société Anonyme des Etablissements Marrel Frères Usine des Etaings, near Rive-de-Gier (Loire), France. (ST. ETIENNE.)

Société Anonyme des Forges de la Providence, Marchienne-au-Pont, Belgium. (*Sections and bars.*) (ANTWERP.)

Société Anonyme des Forges de Vireux-Molhain, Vireux Molhain (Ardennes), France. (*Plates, bars and sections.*) (VALENCIENNES.)

Société Anonyme des Forges et Laminoirs de Baume, Haine St. Pierre, Belgium. (*Rolling Mills for bars and sections.*) (ANTWERP.)

Société Anonyme des Forges, Usines & Fonderies de Haine St. Pierre, Haine St. Pierre, Belgium. (*Steel castings.*) (ANTWERP.)

Société Anonyme des Hauts-Fourneaux, Forges et Aciéries de Pompey, Usines de Pompey, France. (*Steel ingots, plates, angles and round bars.*) (VALENCIENNES.)

Société Anonyme des Hauts-Fourneaux, Forges et Aciéries de Pompey, Division Dieulouard, France. (*Steel ingots, blooms, billets and bars.*) (VALENCIENNES.)

Société Anonyme des Laminoirs, Hauts-Fourneaux, Forges & Fonderies de la Providence, Hautmont (Nord), France (*Steel ingots, plates and sections.*) (VALENCIENNES.)

Société Anonyme des Usines et Aciéries de Sambre et Meuse, Usines de Jeumont, Jeumont (Nord), France. *Steel castings.*) (VALENCIENNES.)

Société Anonyme des Usines et Acieries, Usines de Feignies, Feignies (Nord), France. (*Steel castings.*) (VALENCIENNES.)

Société Anonyme des Usines Gilson, La Croyère (Bois d'Haine), Belgium. (*Steel ingots, blooms, sections and rivet bars.*) (ANTWERP.)

Société Anonyme d'Ougrée-Marihaye, Ougrée, near Liége Belgium. (ANTWERP.)

Société Anonyme Forges et Laminoirs de Jemappes, Jemappes, near Mons, Belgium. (*Ingots, blooms and bars.*) (ANTWERP.)

Société Anonyme John Cockerill. (*Works* at Seraing Belgium.) (*Works* at Grivegnée.) (*Steel ingots and bars.*) (ANTWERP.)

Société Anonyme La Brugeoise et Nicaise & Delcuve, St, Michel-lez-Bruges, Belgium. (*Steel ingots and castings.*) (ANTWERP.)

Société Anonyme Louvroil-Montbard-Aulnoye, Aulnoye (Nord), France. (*Weldless rolled or drawn steel tubes.*) (VALENCIENNES.)

Société Anonyme Usines & Aciéries Leonard-Giot, Marchienne-au-Pont, Belgium. (*Steel castings.*) (ANTWERP.)

Société Anonyme Usines Metallurgiques du Hainaut, Couillet, Belgium. (*Steel forgings, castings, bars and sections.*) (ANTWERP.)

Société des Aciéries de Longwy, Mont St. Martin (Meurthe et Moselle), France. (VALENCIENNES.)

Société des Aciéries de Longwy, Exploitation des Hauts-Fourneaux et Aciéries de Thionville, Thionville (Moselle), France. (*Steel forgings.*) (VALENCIENNES.)

Société des Usines de Louis de Roll, Gerlafingen, Switzerland. (*Steel ingots, round bars, and forgings.*) (WINTERTHUR.)

Sorel Industries, Ld., Sorel, P.Q., Canada. (*Steel ingots and forgings.*) (MONTREAL.)

Sorel Steel Foundries Ld., Sorel, P.Q., Canada. (*Steel castings.*) (MONTREAL.)

Sosnowieckie Towarzystwo Fabryk Rur i Zelaza, Sosnowiec, Katowice, Poland. (*Seamless steel tubes and steel castings.*) (KATOWICE.)

South African Iron & Steel Industrial Corporation, Ld., "Iscor" *Works* at Pretoria, Transvaal, S. Africa. (*Steel ingots, billets, sections and thin plates up to* $\frac{3}{8}$ *in. thick.*) (DURBAN.)

Stabilimenti di Dalmine, Società Anonima, Dalmine (Bergamo), Italy. (*Weldless rolled or drawn steel tubes, hollow pillars and davits.*) (GENOA.)

Stahl und Rohrenwerke Reisholz A.G., Abt. Oberbilk, Germany. (*Steel ingots and forgings.*) (DUSSELDORF.)

Stahl & Walzwerk Grossenbaum, Duisburg-Grossenbaum, Germany. (*Steel bars.*) (DUSSELDORF.)

Stahlwerk Osnabruck A.G., Osnabruck, Germany. (*Steel forgings and castings.*) (DUSSELDORF.)

Standard Steel Works Co., Burnham, Mifflin County, Pa., U.S.A. (*Steel castings and forgings.*) (PHILADELPHIA.)

Stavanger Electro-Staalverk A.S., Stavanger, Norway. (*Steel castings.*) (BERGEN.)

Steel Company of Australia, Coburg, Melbourne. (*Steel castings.*) (MELBOURNE.)

Steel Company of Canada, Hamilton, Ontario. *Works* at Hamilton. (TORONTO.) *Works* at Montreal. (*Bars and angles, steel plates and billets.*) (MONTREAL.)

Stora Kopparbergs Bergslags Aktiebolag, Falun, Sweden. (*Steel Works* at Domnarfvet.) (*Sections of all sizes and plates up to* $1\frac{1}{4}$ *ins. thick; steel castings.*) (STOCKHOLM.)

Sucesora de Aceros Electricos S.A., Barcelona, Spain. (*Steel castings.*) (BARCELONA.)

Sulzer Frères, Société Anonyme, Winterthur, Switzerland. (*Steel castings.*) (WINTERTHUR.)

Surahammars Bruks Aktiebolag, Surahammar, Sweden, (*Forge and Rolling Mills, also steel castings.*) (STOCKHOLM.)

Tata Iron & Steel Co., Ld., Jamshedpur, India. (*Steel plates, angles and channels.*) (CALCUTTA.)

Tennessee Coal, Iron & Railroad Co., Birmingham, Ala., U.S.A. (*Steel Works* at Ensley, Ala., and *Rolling Mills, also forgings*, at Bessemer and Fairfield, Ala.) (MOBILE.)

"Terni" Società per l'Industria e l'Elettricità (*Works* at Terni.) (*Steel ingots, forgings, castings and plates.*) (NAPLES.)

Thompson's (Castlemaine) Ld., Williamstown, Victoria. (*Steel castings.*) (MELBOURNE.)

Tokyo Steel Casting Co., Ld., Tokyo, Japan. (*Steel castings.*) (Yokohama.)

Tosi (Franco), Legnano, Italy. (*Steel forgings and castings.*) (GENOA.)

Travaux Metalliques de Boom, Société Anonyme, Boom, Belgium. (*Small steel castings.*) (ANTWERP.)

Trenton Steel Works, Trenton, N.S. (*Steel forgings.*) (HALIFAX, N.S.)

Uddeholms Aktiebolag, Uddeholm, Sweden. Nykroppa, Sweden. (*Steel ingots, forgings and bars.*) Storfors, Sweden. (*Weldless steel tubes*) and Hagfors, Sweden. (*Steel castings.*) (GOTHENBURG.)

Union des Aciéries, Société Anonyme, Marcinelle, Charleroi, Belgium. (*Steel castings.*) (ANTWERP.)

Union Siderurgique du Nord de la France.

USINOR GROUPE A.

Usines de, Denain, Denain (Nord.) (*Steel ingots, plates, sections and steel castings.*) (VALENCIENNES.)

USINOR GROUPE B.

Usines D'Hautmont, Hautmont (Nord.) (*Steel ingots and plates.*) (VALENCIENNES.)

Usines de Valenciennes, Valenciennes (Nord.) (*Steel) ingots, forgings, blooms, bars and sections.*) (VALENCIENNES.)

Union Steel Corporation of South Africa, Ld. "Usco" *Steel Works and* "Saban" *Rivet Works* at Vereeniging, Transvaal, South Africa. (*Steel ingots, billets, small sections, also steel castings.*) (DURBAN.)

United Steel Works (National Corporation) Prague-Kladno, Czechoslovakia.

Works:

Hradek Rokycany Steel Works, Rokycany. (*Steel ingots, bars and sections.*) (PILSEN.)

Koniev Steel Works, Kladno. (*Steel ingots, bars and sections.*) (PILSEN.)

Poldi Steel Works, Kladno. (*Alloy steel forgings, castings bars and sections.*) (PILSEN.)

Uraga Dock Co., Ld., Uraga, Japan. (*Steel castings.* (YOKOHAMA.)

Usines & Aciéries Allard, Société Anonyme, Mont-sur-Marchienne, near Charleroi, Belgium. (*Steel castings.*) (ANTWERP.)

Usines & Acieries Allard, Société Anonyme, Turnhout, Belgium. (*Small steel castings.*) (ANTWERP.)

Usines Emile Henricot, Court St. Etienne, Belgium. (*Steel castings.*) (ANTWERP.)

Usines Gustave Boël (Aciéries de la Louvière), La Louvière, Belgium. (*Steel ingots, forgings, castings, plates and bars.*) (ANTWERP.)

Vancouver Engineering Works, Ld., Vancouver, B.C. (*Steel castings.*) (VANCOUVER, B.C.)

Varde Staalvaerk, Varde, Denmark. (*Steel ingots and castings.*) (COPENHAGEN.)

Vereinigte Oesterreichische Eisen-und-Stahlwerke Aktiengesellschaft, Linz a.d. Donau, Upper Austria. (*Steel plates.*) (VIENNA.)

Vickers Ruwolt Pty., Ld., Richmond, Melbourne, Australia. (*Steel castings.*) (MELBOURNE.)

Victoria Machinery Depot Co., Ld., Victoria, B.C., Canada. (*Steel castings.*) (VANCOUVER.)

Vitkovice Steel Works (National Corporation) Ostrava, Czechoslovakia. (PILSEN.)

Vulcar Iron & Engineering Ld., Winnipeg, Manitoba, Canada. (*Steel castings.*) (MONTREAL.)

Washington Iron Works, Seattle, Wash., U.S.A. (*Steel castings.*) (SEATTLE.)

Wendel, Les Petits Fils de F^{ois} de, Usine "Fenderie", Hayange, (Moselle), France. (VALENCIENNES.)

Worth Steel Co., Claymont, Del., U.S.A. (*Steel plates.*) (PHILADELPHIA.)

Zelezarna Jesenice, Jesenice, Yugoslavia. (SPLIT.)

Zeljezara Zenica, Zenica, Yugoslavia. (*Bars and sections.*) (SPLIT.)

FIRMS IN COUNTRIES OTHER THAN GREAT BRITAIN AND IRELAND.

ARRANGED ACCORDING TO SURVEYING DISTRICTS.

In Germany and Japan, and in countries which were occupied by forces from these nations, information regarding the steel works is still incomplete and names of the works have only been included if inspection has been carried out since the war.

ADELAIDE.

Mason & Cox Ld., Adelaide, S. Australia. (*Steel castings.*)

AMSTERDAM.

G. Dikkers & Co., N.V., Hengelo, Holland. (*Small steel castings.*)

Koninklyke Nederlandsche Hoogovens & Staalfabrieken N.V. (Royal Netherlands Blast-Furnaces & Steel Works, Ld.), Ymuiden, Holland. (*Plates and sections.*)

ANTWERP.

Aciéries de Haine St. Pierre et Lesquin, Société Anonyme, Haine St. Pierre. (*Steel castings.*)

Aciéries & Minières de la Sambre,

Works at Monceau-sur-Sambre. (*Rolling Mills for bars.*)

Works at Nimy. (*Rolling Mills for bars.*)

Aciéries Reunies de Burbach-eich-Dudelange, (Arbed.) Division de Dommeldange, Dommeldange, Luxembourg. (*Steel ingots, forgings and castings.*)

Division de Dudelange, Greisendahl, Luxembourg. (*Rolling mills for plates up to 8 mm. in thickness.*)

Division de Belval, Esch-sur-Allzette, Luxembourg. (*Steel ingots, blooms, billets, bars and angle bars.*)

Division d'Esch, Esch-sur-Allzette, Luxembourg. (*Rolling mills for bars and sections.*)

Compagnie Generale des Aciers, Société Anonyme, Thy-le-Chateau, Belgium. (*Steel castings.*)

Société Anonyme de la Fabrique de Fer de Charleroi, Charleroi. (*Steel ingots and plates.*)

Société Anonyme d'Ougrée-Marihaye, Ougrée, near Liége.

Société Anonyme des Forges et Laminoirs de Baume, Haine St. Pierre. (*Rolling Mills for bars and sections.*)

Société Anonyme des Forges, Usines & Fonderies de Haine St. Pierre, Haine St. Pierre. (*Steel castings.*)

Société Anonyme des Usines Gilson, La Croyère (Bois d'Haine.) (*Steel ingots, blooms, sections, and rivet bars.*)

Société Anonyme des Forges de la Providence, Marchienne-au-Pont, Belgium. (*Sections and bars.*)

Société Anonyme Forges et Laminoirs de Jemappes, Jemappes, near Mons, Belgium. (*Ingots, blooms and bars.*)

Société Anonyme John Cockerill.

Works at Seraing.

Works at Grivegnée. (*Steel ingots and plates.*)

Société Anonyme La Brugeoise et Nicaise & Delcuve, St. Michel-lez-Bruges. (*Steel ingots and castings.*)

Société Anonyme Usines & Aciéries Leonard-Giot, Marchienne-au-Pont. (*Steel castings.*)

Société Anonyme Usines Metallurgiques du Hainaut, Couillet. (*Steel forgings, castings, bars and sections.*)

Travaux Metalliques de Boom, Société Anonyme, Boom. (*Small steel castings.*)

Union des Aciéries, Société Anonyme, Marcinelle, Charleroi. (*Steel castings.*)

Usines & Aciéries Allard, Société Anonyme, Mont-sur-Marchienne, near Charleroi. (*Steel castings.*)

Usines & Aciéries Allard, Société Anonyme, Turnhout, (*Small steel castings.*)

Usines Emile Henricot, Court St. Etienne. (*Steel castings.*)

Usines Gustave Boël (Aciéries de la Louvière), La Louvière. (*Steel ingots, forgings, castings, plates and bars.*)

BALTIMORE, MD.

Bethlehem Steel Co., Sparrows Point, Md., U.S.A.

BARCELONA.

Altos Hornos de Vizcaya, S.A., Fabrica de Sagunto, Sagunto, Spain. (*Steel ingots, bars and sections.*)

Fundiciones Escorsa S.A., Pi y Margall, 2-Hospitalet de Llobregat, Barcelona, Spain. (*Steel castings.*)

La Maquinista Terrestre y Maritima S.A., Barcelona, Spain. (*Steel castings and forgings.*)

Sociedad Anonima Industrias Mecanicas, Barcelona, Spain. (*Steel castings.*)

Sucesora de Aceros Electricos S.A., Barcelona, Spain (*Steel castings.*)

BERGEN.

Stavanger Electro-Staalwerk A.S., Stavanger, Norway. (*Steel castings.*)

BILBAO.

Aceros de Llodio, Ltda., Llodio, near Bilbao, Spain. (*Small steel castings, ingots and forgings.*)

Compañia Anonima Basconia, Bilbao, Spain.

Compañia Auxiliar de Ferrocarriles, Beasain, Guipuzcoa, Spain. (*Small steel castings and forgings.*)

Compañia Euskalduna, Talleres de Elorrietta, Bilbao, Spain. (*Steel castings.*)

Fabrica Nacional de Trubia, Trubia Asturias, Spain. (*Steel castings and forgings.*)

Luzuriaga, Victorio, S.L., Pasajes, Guipuzcoa, Spain. (*Steel castings.*)

Sociedad Altos Hornos de Vizcaya, Bilbao, Spain.

Sociedad Anonima Echevarria, Bilbao, Spain. (*Small sections and bars.*)

Sociedad Industrial Asturiana, "Santa Barbara," Fabricas de Moreda y Gijon, Gijon, Spain. (*Rivet bars.*)

Sociedad Anonima Jose Maria Quijano, Forjas de Los Corrales de Buelna, Provincia de Santander, Spain. (*Steel bars.*)

Sociedad Anonima Talleres de Deusto, Deusto, Bilbao, Spain. (*Steel castings.*)

Sociedad Española de Construcciones Babcock & Wilcox, Domicilo social: Calle Ercilla 1, Bilbao.
Fabrica: Galindo-San Salvador del Valle. (Vizcaya.) (*Steel castings, ingots and forgings.*)

Sociedad Española de Construccion Naval. *Works* at Reinosa, near Santander, Spain. (*Steel ingots, forgings, castings, plates and sections.*)

Works at Sestao, near Bilbao. (*Small steel castings, ingots and forgings.*)

Sociedad Metalurgica Duro-Felguera, La Felguera, Asturias, Spain. (*Steel ingots, billets, castings, plates and sections.*)

BUDAPEST.

Manfred Weiss Steel & Metal Works, National Enterprise, Budapest-Csepel, Hungary. (*Steel tubes.*)

MAVAG—Metallurgical Works, National Enterprise, Budapest-Diosgyor, Hungary. (*Steel castings, forgings, plates and sections.*)

Rimanurany Metallurgical Works, National Enterprise, Budapest-Ozd, Hungary. (*Ingots, plates, bars and sections.*)

CADIZ.

Sociedad Espanola de Construccion Naval, San Carlos Factory, San Fernando, Cadiz. (*Steel castings.*)

CALCUTTA.

Bengal Steel Corporation, Burnpur, India. (*Sections and angles.*)

Tata Iron & Steel Co., Ld., Jamshedpur, India. (*Steel plates, angles and channels.*)

CHICAGO, ILL.

Carnegie-Illinois Steel Corporation, Chicago, Ill., U.S.A.

Colorado Fuel & Iron Corporation, Minnequa Works, Pueblo, Colorado, U.S.A. (*Steel ingots, bars and small sections.*)

Finkl (A.) & Sons Company, Chicago, Ill., U.S.A. (*Steel forgings.*)

Inland Steel Co., Indiana Harbor, Ind., U.S.A. (*Steel ingots, blooms, billets and slabs.*)

Republic Steel Corporation, Cleveland, O., U.S.A.

Chicago Plant, Chicago, Ill., U.S.A. *Steel Works* at 118th Street, Chicago, and *Rolling Mills* at East Chicago, Ind. (*Steel angles and bars.*)

CLEVELAND, O.

American Rolling Mill Co., Middletown, O., U.S.A. (*Steel castings and forgings.*)

Bethlehem Steel Co., Buffalo, N.Y., U.S.A.

Erie Forge Co., Erie, Pa., U.S.A. (*Steel ingots, forgings and castings.*)

Falk Corporation, Milwaukee, Wis., U.S.A. (*Steel castings.*)

National Enameling & Stamping Co., Granite City, Ill., U.S.A.

National Malleable and Steel Castings Co., Sharon, Pa., U.S.A. (*Steel ingots and steel castings.*)

Republic Steel Corporation, Cleveland, O., U.S.A.

Buffalo Plant, Buffalo, N.Y., U.S.A.

Central Alloy District, Massillon Plant, Massillon, O., U.S.A.

Cleveland District, Cleveland, O., U.S.A.

Corrigan McKinney Plant. (*Steel ingots, blooms and billets.*)

Upson Nut Plant. (*Round and square steel bars.*

COPENHAGEN.

Burmeister & Wain's Maskin-og Skibsbyggeri, Aktieselskabet, Copenhagen, Denmark. (*Steel ingots, forgings and castings.*)

Danske, (Det), Staalvalsevaerk A/S., Frederiksvaerk, Denmark. (*Plates, sections and bars.*)

Helsingør Skibsvaerft-og Maskinbyggeri A/S., Aktieselskabet, Elsinore, Denmark. (*Steel ingots, forgings and castings.*)

Varde Staalvaerk, Varde, Denmark. (*Steel ingots and castings.*)

DORTMUND.

Dortmund-Horder Hüttenverein, Dortmund. (*Steel bars and sections.*)

Hüttenwerke Haspe A.G., Hagen-Haspe (Dortmund.) (*Steel ingots, plates, bars and sections.*)

Hüttenwerke Hoerde A.G., Dortmund-Hoerde. (*Steel ingots, plates, sections, bars, forgings and castings.*)

Ruhrstahl A.G., Henrichschütte, Hattingen-Ruhr. (*Steel ingots, plates, forgings and steel castings.*)

DURBAN.

Dunswart Iron & Steel Works, Ld., Benoni, South Africa. (*Steel castings, ingots, billets, and small sections.*)

Iscor Vanderbyl Works, Plate Division, Houlkop, near Vereeniging, South Africa. (*Rolling mills for plates.*)

South African Iron & Steel Industrial Corporation, Ld., "Iscor" Works at Pretoria, Transvaal, S. Africa. (*Steel ingots, billets, sections and thin plates up to $\frac{3}{8}$ in. thick.*)

Union Steel Corporation of South Africa, Ld., "Usco" Steel Works and "Saban" Rivet Works at Vereeniging, Transvaal, S. Africa. (*Steel ingots, billets, small sections, also steel castings.*)

DUSSELDORF.

Forges et Aciéries de Volklingen, Gestion Francaise des Ancinnes Usines Rochling, Volklingen (Sarre). (*Ingots, billets, bars and forgings, including alloy steels.*)

Georgs-marienhütte A.G., Osnabruck. (*Steel ingots and bars.*)

Gussstahlwerk Oberkassel Aktiengesellschaft, Dusseldorf- Oberkassel. (*Steel castings.*)

Gutehoffnungshütte Oberhausen A.G., Oberhausen. (*Steel forgings.*)

Hüttenwerk Huckingen A.G., Duisburg. (*Steel ingots, plates, sections and bars.*)

Hüttenwerk Oberhausen A.G., Oberhausen. (*Steel ingots, plates, sections and bars.*)

Hüttenwerk Rheinhausen A.G., Rheinhausen. (*Bars and sections only.*)

Rheinische Röhrenwerke A.G., Mulheim-Ruhr. (*Plates.*)

Stahl und Rohrenwerke Reisholz A.G., Abt. Oberbilk. (*Steel ingots and forgings.*)

Stahl und Walzwerke Grossenbaum A.G., Grossenbaum. (*Steel bars.*)

Stahlwerk Osnabrück A.G., Osnabrück. (*Steel forgings and castings.*)

GENOA.

A.S.S.A. Acciaierie di Susa Società Anonima, Torino, Italy. *Head Office* at Turin. *Works* at Susa. (*Steel castings.*)

Acciaieria e Ferriera del Caleotto - Società Anonima, Lecco, Italy. (*Steel ingots, bars, small sections and small forgings.*)

Acciaieria e Tubificio di Brescia, Società Anonima, Brescia. (*Steel ingots, sections and bars, steel castings, weldless or water gas welded tubular materials.*)

Acciaierie e Ferriere Lombarde Falck. *Head Office*, Milan. *Works* at Milan. (*Weldless rolled or drawn steel tubes.*)

Concordia Works at Sesto S. Giovanni. (*Rolling mills for steel plates.*)

Unione *Works* at Sesto S. Giovanni. (*Steel ingots, sections, bars, forgings, also steel castings.*)

Acciaierie Elettriche Pio Faggian, La Spezia, La Spezia. (*Small steel castings.*)

Ansaldo Società Anonima, Stabilimento Fossati, Genoa-Sestri. (*Steel forgings.*)

Fabrica Italiana Tubi, Società Anonima, Sestri Levante, Italy. (*Steel ingots, billets and weldless rolled and drawn steel tubes.*)

Fonderie Acciaierie Milanesi Vanzetti, Milan. (*Steel castings.*)

Fonderie Elettriche Pracchi, Milan. (*Small steel castings.*)

Fratelli Bruzzo-Ferriera di Bolzaneto, Genova-Bolzaneto (*Steel plates, sections and bars.*)

Giovanni Villa - Società Anonima Officine Meccaniche - Fucinati - Stampati, Milan. (*Steel forgings.*)

"Ilva" Alti Forni e Acciaierie d'Italia: *Head Office*, Genoa.

Stabilimento di Genova-Bolzaneto. (*Sections and bars.*)

Stabilimento di Genova-Voltri. (*Rivets.*)

Stabilimento di Lovere. (*Sections, bars, castings and forgings.*)

Stabilimento di Novi Ligure. (*Sections, bars and plates.*)

Stabilimento di Porto Vecchio di Piombino. (*Steel ingots, blooms, sections and bars.*)

Stabilimento di Savona. (*Sections, bars and plates.*)

Metallurgica Vittorio Cobianchi Soc. An. Head Office in Milan; Steel Works at Omegna (Novara). (*Steel castings.*)

"Reggiane" Officine Meccaniche Italiane S.p.A.-Reggio, Emilia. (*Steel forgings.*)

Società Anonima Acciaierie Elettriche di Sesto San Giovanni, Sesto San Giovanni, Milan. (*Steel castings.*)

Società Anonima Fonderie Acciaierie Liguri, Genova-Sampierdarena. (*Small steel castings.*)

Società Anonima Nazionale "Cogne" (*Head Office*, Turin: *Works* at Aosta.) (*Steel ingots, forgings plates, sections and bars.*)

Società Italiana Acciaierie Cornigliano (*Head Office* at Genova-Cornigliano.) (*Steel ingots, forgings, plates, castings and sections.*)

Società Italiana Ernesto Breda Sesto S. Giovanni, Milan, (*Steel ingots, sections, forgings and steel castings.*)

Società per Azioni Acciaierie di Bolzano, Bolzano. (*Steel ingots, billets, rolled bars, forgings and steel castings.*)

Società per Azioni FIAT-Sezione Ferriere Piemontesi, Turin. (*Steel ingots, plates, sections, also seamless and welded tubes.*)

Società per Azioni FIAT-Sezione Industrie Metallurgiche Acciaierie, Turin. (*Steel castings and forgings.*)

Stabilimenti di Dalmine, Società Anonima, Dalmine (Bergamo.) (*Weldless rolled or drawn steel tubes, hollow pillars and davits.*)

Tosi (Franco), Legnano, Italy. (*Steel forgings and castings.*)

GOTHENBURG.

Aktiebolaget Bofors, Bofors, Sweden. (*Melting Furnaces and Foundry.*)

Aktiebolaget Motala Verkstad, Motala Verkstad. Sweden. (*Melting Furnaces, Rolling Mills and Forge; also steel castings.*)

Björneborgs Jernverks Aktiebolag, Björneborg, Sweden. (*Melting Furnaces and Forge.*)

Degerfors Järnverks Aktiebolag, Degerfors, Sweden (*Melting Furnaces and Rolling Mills.*)

Hellefors Bruks Aktiebolag, Hällefors, Sweden. (*Steel bars.*)

Uddeholms Aktiebolag, Uddeholm, Sweden. Nykroppa, Sweden. (*Steel ingots, forgings and bars.*) Storfors, Sweden. (*Weldless steel tubes.*) Hagfors, Sweden. (*Steel castings.*)

HALIFAX, N.S.

Dominion Steel & Coal Corporation Ld., Sydney, N.S. (*Steel ingots, billets and sections.*)

Maritime Steel Foundries, Ld., New Glasgow, N.S. (*Small steel castings.*)

Trenton Steel Works, Trenton, N.S. (*Steel forgings.*)

KATOWICE.

Centralny Zarzad Premyszlu Hutniciego, Katowice, Poland.

Huta Baildon, Katowice, GS/I, Poland. (*Steel ingots, blooms, billets, bars and sections.*)

Huta Bankowa, Dabrowa Gornicza G/S, Poland. (*Steel ingots, sections, bars, castings and forgings.*)

Huta Batory, Katowice, Poland. (*Steel ingots, plates, forgings, weldless rolled tubes and hollow pillars.*)

Huta Florian, Swietochlowice, Poland. (*Rolled bars and sections.*)

Huta Kosciuszko, Chorzow, Poland. (*Rolled steel sections.*)

Huta Laura, Siemianowice, Poland. (*Seamless steel tubes.*)

Huta Ostrowiec, Ostrowiec, Poland. (*Rolled bars and sections.*)

Huta Pokoj, Nowy Bytom, Poland.

Huta Stalowa Wola, Katowice, Poland. (*Plates and forgings.*)

Huta Zawiercze, Zawiercze, Poland. (*Rolled bars and sections.*)

Sosnowieckie Towarzystwo Fabryk Rur i Zalaza, Sosnowiec, Katowice, Poland. (*Seamless steel tubes and steel castings.*)

KOBE.

Amagasaki Iron & Steel Manufacturing Co., Ld., Kure Works, Kure, Japan. (*Ingots and steel castings.*)

Fuso Metal Industries, Ld., Steel Tube Works, Amagasaki, Japan. (*Ingots, small bars and sections, weldless steel tubes.*)

Steel Works, Osaka, Japan. (*Steel castings and forgings.*)

Harima Shipbuilding Works, Ld., Harima, Japan. (*Steel castings and forgings.*)

Japan Iron & Steel Co., Ld., Yawata, Japan. (*Steel plates, sections, steel ingots and forgings.*)

Kawasaki Heavy Industries, Ld., Fukai Plant, Kobe, Japan. (*Steel plates.*)

Hyogo Plant, Kobe, Japan. (*Steel castings and forgings.*)

Kobe Steel Works, Ld., Kobe, Japan. (*Steel castings and forgings.*)

Mitsubishi Steel Works Co., Ld., Nagasaki, Japan. (*Steel ingots, blooms, forgings and castings.*)

Mitsui Shipbuilding & Engineering Co., Ld., Tamano, Japan. (*Steel forgings and castings.*)

Nippon Steel Foundry Ld., Osaka, Japan. (*Steel castings.*)

Osaka Chain & Machinery Manufacturing Co., Ld., Kaizurka Works, Osaka, Japan. (*Small steel castings.*)

Sasebo Ship Industry Co., Ld., Sasebo, Japan. (*Steel castings and forgings.*

LISBON.

Companhia União Fabril, Lisbon, Portugal. (*Steel castings.*)

Companhia União Fabril, Barreiro, Portugal. (*Steel castings.*)

LOS ANGELES.

Bethlehem Pacific Coast Steel Corporation, Los Angeles 54, Cal., U.S.A. (*Round bars.*)

Columbia Steel Company, Torrance, Cal., U.S.A. (*Round bars, sections and sheets, also steel castings.*)

Geneva Steel Company (United States Steel Corp., Subsidiary.), Geneva, Utah, U.S.A. (*Steel plates.*)

Kaiser Company, Inc., Iron and Steel Division, Fontana, Cal., U.S.A. (*Steel ingots and plates.*)

Los Angeles Steel Casting Co., Los Angeles, Cal., U.S.A. (*Steel castings.*)

MALMÖ.

Aktiebolaget Abjörn Anderson, Svedala, near Malmö, Sweden. (*Steel castings.*)

Kockums Jernverk, Kallinge, Sweden. (*Steel castings.*)

MELBOURNE.

Melbourne Iron and Steel Mills Pty., Ld., Brooklyn, Melbourne. (*Steel ingots.*)

Steel Company of Australia, Coburg, Melbourne. (*Steel castings.*)

MELBOURNE.—*continued.*

Thompson's (Castlemaine) Ld., Williamstown, Victoria. (*Steel castings.*)

Vickers Ruwolt Proprietary, Ld., Richmond, Melbourne. (*Steel castings.*)

MOBILE, ALA.

Republic Steel Corporation, Alabama City, Alabama, U.S.A.

Tennessee Coal, Iron & Railroad Co., Birmingham, Ala., U.S.A. (*Steel Works* at Ensley, Ala., and *Rolling Mills, also forgings,* at Bessemer and Fairfield, Ala.)

MONTREAL.

Canadian Car and Foundry, Steel Foundry Division, Longue Pointe, Montreal, Canada. (*Steel castings.*)

Canadian Tube and Steel Products, Ld., 5765, Hamilton Street, Montreal, P.Q., Canada. (*Steel angles, bars and rivets.*)

Canadian Unitcast-Steel, Ld., Sherbrooke, Quebec, Canada. (*Steel castings.*)

Lynn Macleod Metallurgy Ld., Thetford Mines, P.Q. (*Steel castings.*)

Manitoba Rolling Mill Co., Ld., Selkirk, Manitoba, Canada. (*Steel castings.*)

Manitoba Rolling Mill Co., Ld., Winnipeg, Manitoba, Canada. (*Steel billets, bars and sections.*)

Sorel Industries, Ld., Sorel, P.Q., Canada. (*Steel ingots and forgings.*)

Sorel Steel Foundries, Ld., Sorel, P.Q., Canada. (*Steel castings.*)

Steel Company of Canada, Hamilton, Ontario, Canada. *Works* at Montreal. (*Bars and angles, steel plates and billets.*)

Vulcan Iron & Engineering, Ld., Winnipeg, Manitoba, Canada. (*Steel castings.*)

NAPLES.

"Ilva Alti Forni e Acciaierie d'Italia: *Head Office* Genoa.

Stabilimento di Bagnoli. (*Steel ingots, sections and bars.*)

Stabilimento di Torre Annunziata, Centrale. (*Steel ingots, sections and bars.*)

Navalmeccanica S/A Officine Meccaniche e Fonderie, Naples, Italy. (*Steel castings.*)

"Terni" Società per Industria e l'Elettricha (*Works* at Terni). (*Steel ingots, forgings, castings, sections, bars and plates*).

NEW YORK.

American Steel Foundries, Newark, N.J., U.S.A. (*Steel castings.*)

NEWCASTLE, N.S.W.

Broken Hill Proprietary Co., Ld., Iron and Steel Works, Newcastle, N.S.W. (*Steel plates, bars, sections and castings.*)

Commonwealth Steel Co., Ld., Waratah, Newcastle, N.S.W. (*Steel castings and forgings.*)

NEWPORT NEWS, VA.

Newport News Shipbuilding & Dry Dock Co., Newport News, Va., U.S.A. (*Steel castings and forgings.*)

OSLO.

A/S Drammens Jernstoberi & Mek-Verksted, Drammen. (*Small steel castings.*)

A/S Strömmens Verksted, near Oslo. (*Steel castings.*)

Christiania Spigerverk, Oslo. (*Steel ingots and bars. also rivet bars.*)

Raufoss Ammunisjonsfabrikker, Raufoss. (*Steel castings.*)

PHILADELPHIA, PA.

Alan Wood Steel Company, Conshohocken and Ivy Rock, Pa., U.S.A. (*Blooms, billets and thin plates.*)

Atlantic Steel Castings Co., Chester, Pa., U.S.A. (*Steel castings.*)

Bethlehem Steel Co., Bethlehem, Pa., U.S.A. (*Steel ingots, forgings, bars and sections.*)

Lebanon, Pa., U.S.A. (*Rolling Mills for bars.*)

Steelton, Pa., U.S.A. (*Steel forgings and castings.*)

Birdsboro Steel Foundry & Machine Co., Birdsboro, Pa., U.S.A. (*Steel castings.*)

Central Iron & Steel Co., Harrisburg, Pa., U.S.A. (*Rolling Mills.*)

Crucible Steel Castings Co., Lansdowne, Pa., U.S.A. (*Steel castings.*)

Dodge Steel Company, Tacony, Philadelphia, Pa., U.S.A. (*Small steel castings.*)

General Steel Castings Corporation, Eddystone, Pa., U.S.A. (*Steel castings.*)

Lebanon Steel Foundry, Lebanon, Pa., U.S.A. (*Small steel castings.*)

Lukens Steel Company, Coatesville, Pa., U.S.A.

Midvale Company (The), Nicetown, Philadelphia, Pa., U.S.A. (*Steel forgings.*)

Penn Steel Castings Corporation, Chester, Pa., U.S.A. (*Steel castings.*)

Pennsylvania Electric Steel Casting Co., Hamburg, Pa., U.S.A. (*Small steel castings.*)

Pennsylvania Forge Corporation, Tacony, Philadelphia, Pa., U.S.A. (*Steel forgings.*)

Phœnix Iron Company, Phœnixville, Pa., U.S.A. (*Sections and bars.*)

Standard Steel Works Co., Burnham, Mifflin County, Pa., U.S.A. (*Steel castings and forgings.*)

Worth Steel Co., Claymont, Del., U.S.A. (*Steel plates.*)

PILSEN.

GROUP I.

Mining and Iron Works Company, National Corporation Iron Works, Trinec, Ostrava. (*Steel bars and sections, steel castings.*)

United Steel Works (National Corporation), Prague-Kladno. *Works:* Hradek Rokycany Steel Works, Rokycany. (*Steel ingots, bars and sections.*)

Koniev Steel Works, Kladno. (*Steel ingots, bars and sections.*)

Poldi Steel Works, Kladno. (*Alloy steel forgings, castings, bars and sections.*)

Vitkovice Steel Works (National Corporation), Ostrava.

GROUP II.

Ceskomoravska-Kolben-Danek Steel Works (National Corporation), Prague. (*Steel forgings and castings.*)

First Brno & Kralovo Pole Engineering Works (National Corporation), Brno. (*Steel castings.*)

Skoda Works (National Corporation), Pilsen. (*Steel forgings and castings; cast steel anchors.*)

PITTSBURGH, PA.

American Locomotive Co., Railway Steel Spring Division, Latrobe, Pa., U.S.A. (*Steel ingots.*)

Bethlehem Steel Co., Cambria Works, Johnstown, Pa., U.S.A.

Carnegie-Illinois Steel Corporation, Pittsburgh, Pa., U.S.A.

Crucible Steel Company of America, Pittsburgh Crucible Division, Midland, Pa., U.S.A.

Jones & Laughlin Steel Corporation, Pittsburgh, Pa., U.S.A.

Mesta Machine Co., West Homestead, Pa., U.S.A. (*Steel ingots, castings and forgings.*)

Pittsburgh Steel Foundry Corporation, Glassport, Pa., U.S.A. (*Castings.*)

Republic Steel Corporation, Cleveland, O., U.S.A.; Youngstown Plant, Youngstown, O., U.S.A.

RIO DE JANEIRO.

Compania Siderurgica Nacional Steel Works, Volta Redonda, Est. do Rio de Janeiro, Brazil. (*Steel plates and sections.*)

ROTTERDAM.

Machine Fabriek Yzer-Staal & Metaal Gieterij (v/h Bakker & Co.), Ridderkerk. (*Steel castings.*)

Nederlandsche Staalfabrieken (v/h J. M. Muinck Keizer), Utrecht, Holland. (*Steel ingots, blooms, billets and castings; also steel rivet bars.*)

ST. ETIENNE.

Compagnie des Forges et Aciéries de la Marine et d'Homecourt, St. Chamond (LOIRE.)

Fonderies, Forges et Aciéries de St. Etienne, St. Etienne.

Schneider & Co., Le Creusot.

Société Anonyme des Etablissements Marrel Frères, Usine des Etaings, near Rive-de-Gier.

SAN FRANCISCO, CAL.

Bethlehem Pacific Coast Steel Corporation, South San Francisco, Cal., U.S.A. (*Steel ingots, small sections and bars.*)

Enterprise Engine & Foundry Co., South City, Cal., U.S.A. (*Steel castings.*)

General Metals Corporation Oakland, Cal., U.S.A. (*Steel castings.*)

Pacific States Steel Corporation, Niles, Cal., U.S.A. (*Steel ingots, sections and bars.*)

Pacific Steel Castings Co., Berkeley, Cal., U.S.A. (*Steel castings.*)

SEATTLE, WASH.

Bethlehem Pacific Coast Steel Corporation, Seattle, Wash., U.S.A. (*Sections and bars.*)

Olympic Steel Works, Seattle, Wash., U.S.A. (*Steel castings.*)

Pacific Car & Foundry Co., Renton, Wash., U.S.A. (*Steel castings.*)

Washington Iron Works, Seattle, Wash., U.S.A. (*Steel castings.*)

SPLIT.

Zelezarna Jesenice, Jesenice, Yugoslavia.

Zeljezara Zenica, Zenica, Yugoslavia. (*Bars and sections.*)

STOCKHOLM.

Aktiebolag Svenska Jarnvagsverkstaderna, Linköping Sweden. (*Steel castings.*)

Aktiebolaget Kanthal, Hallstahammar, Sweden. (*Steel castings and rivet bars.*)

Aktiebolaget Nordiska Armaturfabrikerna, Linköping, Sweden. (*Steel castings.*)

Avesta Jernverks Aktiebolag, Avesta, Sweden. (*Steel plates, sections and castings; also high pressure air receivers.*)

Fagersta Bruks Aktiebolag, Fagersta, Sweden (Brukskoncernen).

Works at Fagersta. (*Steel blooms and billets, forgings and rolled bars.*)

Works at Forsbacka. (*Steel blooms, billets, tubes and forged and rolled bars.*)

Works at Horndal (*Steel bars and angles.*)

Works at Osterbybruk. (*Steel castings.*)

STOCKHOLM—*continued.*

Hallstahammars Aktiebolag, Hallstahammar, Sweden. (*Steel Bars.*)

Kohlswa Jernverks Aktiebolag. (*Melting Furnaces Foundry, Forge and Rolling Mills for bars and small sections* at Kolsva, Sweden.)

Ramnas Bruks Aktiebolag, Ramnas, Sweden. (*Rolling mills for bars.*)

SKF. Hofors Bruk, Hofors, Sweden. (*Steel billets, bars and forgings and thick walled tubes.*)

Sandvikens Jernverks Aktiebolag, Sandviken, Sweden. (*Steel ingots, forgings, and steel tubes.*)

Smedjebackens Valsverks Aktiebolaget, Smedjebacken, Sweden. (*Steel sections and castings.*)

Stora Kopparbergs Bergslags Aktiebolag, Falun, Sweden. (*Steel Works* at Domnarfvet.) (*Sections of all sizes and plates up to* 1¼ *ins. thick; steel castings.*)

Surahammars Bruks Aktiebolag, Surahammar, Sweden. (*Forge and Rolling Mills, also steel castings.*)

SYDNEY, N.S.W.

Australian Iron & Steel, Ld., Port Kembla, N.S.W. (*Steel plates, bars, sections and forgings.*)

Bradford, Kendall, Ld., Alexandria, Sydney, N.S.W. (*Steel castings.*)

Hadfields Steel Works, Ld., Alexandria, Sydney, N.S.W. (*Steel castings.*)

Industrial Steels, Ld., Lidcombe, Sydney, N.S.W. (*Steel castings.*)

TORONTO, ONTARIO.

Algoma Steel Corporation, Ld., Sault St. Marie, Ontario, Canada. (*Steel billets, bars and angles.*)

Atlas Steels Ld., Welland, Ontario, Canada. (*Steel ingots and bars.*)

Canada Foundries & Forgings, Ld., Welland, Ontario, Canada. (*Steel forgings.*)

Dominion Foundries & Steel, Ld., Hamilton, Ontario, Canada. (*Steel ingots, plates and castings.*)

Steel Company of Canada, Hamilton, Ontario, Canada, (*Bars and angles, steel plates and billets.*)

TRIESTE.

Acciaierie Valbruna di Ernesto Gresele, Vicenza. (*Steel castings, bars, sections and forgings.*)

"Ilva" Alti Forni e Acciaierie d'Italia: *Head Office*, Genoa.

Stabilimento di Marghera. (*Steel castings, also Rolling Mills for small steel sections and bars.*)

Stabilimento di Servola. (*Steel ingots, billets and plates.*)

Società Anonima Fonderie Officine di Gorizia, Gorizia (*Small steel castings.*)

Società Anonima Officine Fratelli Bertoli fu Rudolfo, Udine. (*Steel castings, forgings, bars and sections*).

VALENCIENNES.

Aciéries et Ateliers de Grosse Forge, Maurice Dembiermont & Cie., Hautmont (Nord). (*Steel forgings*).

Compagnie de Fives Lille, Societe Anonyme, Fives-Lille (Nord). (*Steel ingots, castings and forgings*).

Compagnie des Forges et Aciéries de la Marine et d'Homécourt, Homécourt (Meuthe-et-Moselle)

Forges et Ateliers de Constructions Electriques de Jeumont, Jeumont (Nord). (*Steel castings*).

Société Anonyme d'Escaut & Meuse, Anzin (Nord). (*Steel ingots and weldless rolled or drawn steel tubes*).

Société Anonyme de la Fabrique de Fer de Mauberge, Louvroil (Nord). (*Steel ingots and plates*).

Société Anonyme dea Aciéries de Haine-St.-Pierre et Lesquin, Lesquin-lez-Lille (Nord). (*Steel castings*).

Société Anonyme des Forges de Vireux-Molhain, Vireux-Molhain (Ardennes). (*Plates, bars and sections*).

Société Anonyme des Hauts-Fourneaux, Forges et Aciéries de Pompey, Usines de Pompey. (*Steel ingots, plates, angles and round bars*).

Société Anonyme des Hauts-Fourneaux, Forges et Aciéries de Pompey, Division Dieulouard. (*Steel ingots, blooms, billets and bars*).

Société Anonyme des Laminoirs, Hauts-Fourneaux, Forges et Fonderies, de la Providence, Hautmont (Nord). (*Steel ingots, plates and sections*).

Société Anonyme des Usines et Aciéries de, Sambre et Meuse, Usines de Feignies, Feignies (Nord). (*Steel castings.*)

Société Anonyme des Usines et Aciéries de Sambre et Meuse, Usines de Jeumont, Jeumont (Nord). (*Steel castings*).

Société Anonyme Louvroil-Montbard-Aulnoye, Aulnoye (Nord). (*Weldless rolled or drawn steel tubes*).

Société des Aciéries de Longwy, Exploitation des Hauts-Fourneaux et Aciéries de Thionville, Thionville, (Moselle). (*Steel forgings*).

Société des Aciéries de Longwy, Mont St. Martin (Meurthe-et-Moselle).

Union Siderurgique du Nord de la France.

USINOR GROUPE A.

Usines de Denain, Denain (Nord). (*Steel ingots plates, sections and steel castings*).

USINOR GROUPE B.

Usines d'Hautmont, Hautmont (Nord). (*Steel ingots and plates*).

Usines de Valenciennes, Valenciennes (Nord). (*Steel ingots, forgings, blooms, bars and sections*).

Wendel, les Petits Fils de F^{ois} de Usine, "Fenderie," Hayange (Moselle).

VANCOUVER, B.C.

A.1. Iron & Steel Foundry Ld., Vancouver, B.C., Canada. (*Small steel castings.*)

Canadian Sumner Iron Works Ld., Vancouver, B.C. (*Small steel castings.*)

Reliance Foundry Co., Ld., Vancouver, B.C., Canada. (*Steel castings.*)

Vancouver Engineering Works, Ld., Vancouver, B.C., Canada. (*Steel castings.*)

Victoria Machinery Depot Co., Ld., Victoria, B.C., Canada. (*Steel castings.*)

VIENNA.

Oesterreichisch-Alpine Montangesellschaft, Vienna.

Works at Donawitz, Styria. (*Plates and sections.*)

Works at Kindberg, Styria. (*Rolling Mills for small sections and bars.*)

Vereinigte Oesterreichische Eisen-und Stahlwerke Aktiengesellshaft, Linz a.d. Donau, Upper Austria. (*Steel plates.*)

WINTERTHUR.

Société Anonyme des Aciéries ci-devant Georges Fischer, Schaffhouse, Switzerland. (*Steel castings.*)

Société des Usines de Louis de Roll, Gerlafingen, Switzerland. (*Steel ingots, round bars and forgings.*)

Sulzer Frères, Société Anonyme, Winterthur, Switzerland. (*Steel castings.*)

YOKOHAMA.

East Japan Heavy Industries, Ld., Yokohama Shipyard & Engine Works, Yokohama, Japan. (*Steel ingots, blooms, small forgings and castings*).

Hakodate Dock Co., Ld., Hakodate Shipyard, Hakodate, Japan. (*Small steel castings and forgings.*)

Ishikawajima Heavy Industries Co., Ld., Tokyo, Japan. (*Steel castings and forgings*).

Japan Iron & Steel Co., Ld., Kamaishi. (*Sections and bars.*)

Japan Steel Works Ld., Muroran, Japan. (*Steel ingots, forgings and castings.*)

Kanto Special Steel Works Ld., Yokohama, Japan. (*Steel forgings.*)

Nippon Soda Co., Ld., Oshima Steel Works, Tokyo, Japan. (*Steel castings and small forgings*).

Nippon Steel Tube Co., Ld.,

Tsurumi Iron & Steel Works, Tsurumi, Yokohama, Japan. (*Steel plates*).

Kawasaki Iron & Steel Works, Kawasaki, Japan. (*Steel tubes, bars and sections*).

Tokyo Steel Casting Co., Ld., Tokyo, Japan. (*Steel castings*).

Uraga Dock Co., Ld., Uraga, Japan. (*Steel castings.*)

LONDON.—*January, 1949.*

PROVING ESTABLISHMENTS.

The following Proving Establishments are recognised by the Committee of Lloyd's Register for the Testing of Anchors and Chains while licensed by the Ministry of Transport for that purpose :—

PRINCIPAL SUPERINTENDENT	Mr H. Murphy. *(Stationed at Netherton).*	
NETHERTON (near Dudley)—Lloyd's Proving House	Superintendent,	
LOW WALKER-ON-TYNE—Lloyd's Proving House	„	Mr. R. J. Vogan.
CHESTER (Saltney)—Lloyd's Proving House	„	Mr. S. Bolton.
GLASGOW—Lloyd's Proving House	„	Mr. L. L. Wright.
CARDIFF—Lloyd's Proving House	„	Mr. F. W. Dovey.
CRADLEY HEATH—Lloyd's Proving House	„	Mr. H. Phillips.

The following Machines have been recognised by the Committee for the testing of Anchors and Chain Cables supplied to ships of other than British Registry (*see* Section 39 of the Rules for Steel Ships):—

In Germany and Japan and in countries which were occupied by forces from these nations, information regarding the proving establishments is still incomplete and their names have only been included if inspection has been carried out since the war.

AUSTRALIA	Falkiner Machinery Co., Proprietary, Ld., South Brisbane, Queensland (for testing Chains up to 100 tons).
BELGIUM	Adh. Demanet, Gosselies, Belgium (for testing chains up to 260 tons).
„	Ed. Demaret & Fils, Heppignies, Nr. Fleurus.
„	The Engineering Co, Rues des Indes, Antwerp.
„	Mercantile Marine Engineering & Graving Dock Co., Antwerp.
„	Société Anonyme des Anciens Etablissements Wattelar-Francq, Jumet.
CANADA	Canada Chain & Forge Co., Ld., Granville Island, Vancouver, B.C.
„	Dominion Chain Co., Ld., Niagara Falls, Ontario.
„	McKinnon-Columbus Chain, Ld., St. Catherine's, Ontario.
FRANCE	Etablissement Sirot-Mestreit, St. Amand-les-Eaux (Nord).
„	Paoli (J.) & Co., Marseilles.
„	Société Anonyme des Chaineries de St. Amand-les-Eaux, Etablissements Dorémieux Fils & Cie., St. Amand-les-Eaux (Nord).
GERMANY	Hansa Kettenfabrik Haunschild & Co., Dortmund.
„	Hüttenwerk Horde A.G., Dortmund-Hoerde, Dortmund (for the testing of Anchors only).
„	Joto-Werk Josef Topp, Kettenfabrik, Warmen (Ruhr.)
„	Kettenwerke Schlieper, Grune, Westphalia.
„	Kettenwerke Schlieper, Sichtigvor, Westphalia.
„	Stuelcken (H. C.) Sohn. Schiffswerft und Maschinenfabrik, Hamburg.
„	Theile (J. D.), Schwerte-Ruhr.
HOLLAND	Koninklijke Nederlandsche Grofsmederij, Leiden.
„	N.V. Anker-& Ketting-Industrie "Schiedam" (Managing Director—P. Th. Verhoeff), Schiedam.

ITALY	Acciaieria e Ferriera del Caleotto S.p.A., Lecco.
„	Acciaierie Weissenfels, Catenificio Fusine di Valromana, Udine (for the testing of Small Chains only.)
„	Società Pignone, *Works* at Leghorn. *Head Office* at Florence.
JAPAN	Kobe Steel Works, Kobe (for the testing of Anchors only).
„	Kokko Chain & Steel Manufacturing Co., Ld., Osaka.
„	Tokyo Steel Casting Co., Ld., Tokyo (for the testing of Anchors only).
SPAIN	Cadenas y Forjádos, S.A., J. M. Olavarri, Bilbao. *Works* at Durango, Vizcaya.
„	Forjas de San Martin de Pedro Framis, Barcelona (for testing Chains up to 16 tons).
„	Hijos di Vicinay, S. en C., Ochandiano, Vizcaya.
SWEDEN	Gunnebo Bruks Aktiebolag, Gunnebobuck, Västervik (for testing Chains up to 20 tons).
„	Ljusne Woxna Aktiebolag, Ljusne.
„	Jarnbirger A/B, Orsa.
„	Ramnäs Bruks Aktiebolag, Ramnäs.
„	Statens Provningsanstalt (Government Establishment), Stockholm.

UNITED STATES	American Chain Co., Braddock, near
„ „	Pittsburgh, Pa.; and York, Pa. (for testing Chains up to 22 tons).
„ „	Baldt Anchor, Chain and Forge Division of the Boston Metals Co., Chester, Pa.
„ „	Bellingham Chain & Forge Co., South Bellingham, Wash.
„ „	Buckeye Steel Castings Co., Columbus, Ohio (for breaking tests on Chain Cables only).
„ „	Carroll Chain Co., Columbus, Ohio.
„ „	Cleveland Chain & Manufacturing Co., Cleveland, Ohio.
„ „	Continental Chain Corporation, Fieldsboro, N.J.
„ „	General Steel Castings Corporation, Eddystone, Pa. (for the testing of Anchors only).
„ „	Johnson-Farmer Chain Co., Lebanon, Pa.
„ „	McKay Company, McKees Rocks, near Pittsburgh, Pa.
„ „	National Erie Co., Erie, Pa. (for the testing, of Anchors only).
„ „	National Malleable and Steel Castings Co., Sharon, Pa.
„ „	Portland Chain Manufacturing Co., Portland, Or.
„ „	Round California Chain Corporation, Ld., South San Francisco, California.
„ „	Seattle Chain Co., 6921, East Marginal Way, Seattle, Wash.
„ „	Taylor (S. G.) Chain Company, Hammond, Indiana.
„ „	Woodhouse Chain Works, Trenton, N.J.

N.B.—Ships supplied with Anchors and Chain Cables tested at any of the Establishments in the foregoing lists will have the notation of "Lloyd's A.&.C.P." in the Register Book, provided that in the case of machines outside Great Britain and Ireland the tests are carried out under the supervision of a Surveyor to the Society.

By order of the Committee,

P. E. CLEMENT,

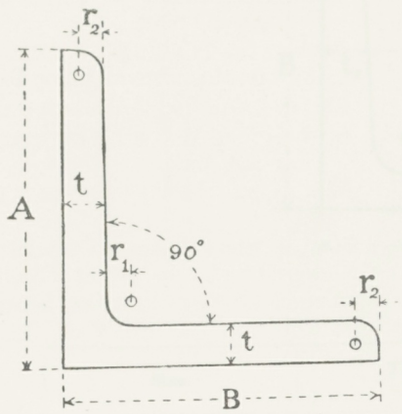
Secretary.

LONDON.—*January, 1950.*

BRITISH STANDARD SECTIONS.

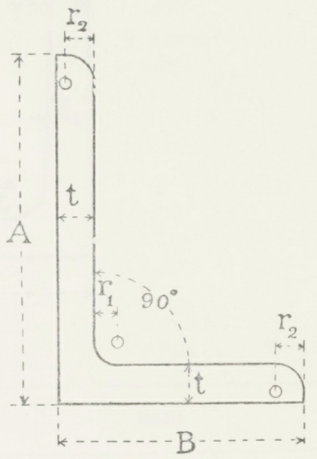
LONDON.—*Revised July, 1920.*

EQUAL ANGLES.



Size.	Thickness at Correct Standard Profile.			Minimum thickness rolled.	Maximum thickness rolled.	Radii.	
A × B	Minimum.	Mean.	Maximum.			Root.	Toe.
	t	t	t			r_1	r_2
Inches.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.
$\frac{3}{4} \times \frac{3}{4}$	·125	—	·250	·125	·250	·17	·12
1 × 1	·125	—	·250	·125	·300	·18	·13
$1\frac{1}{4} \times 1\frac{1}{4}$	·125	—	·250	·125	·300	·20	·14
$1\frac{1}{2} \times 1\frac{1}{2}$	·125	—	·250	·125	·350	·21	·15
$1\frac{3}{4} \times 1\frac{3}{4}$	·175	—	·300	·175	·375	·23	·16
2 × 2	·175	—	·300	·175	·400	·24	·17
$2\frac{1}{4} \times 2\frac{1}{4}$	·175	—	·300	·175	·450	·26	·18
$2\frac{1}{2} \times 2\frac{1}{2}$	·250	·375	·500	·200	·500	·27	·19
$2\frac{3}{4} \times 2\frac{3}{4}$	·250	·375	·500	·225	·525	·29	·20
3 × 3	·250	·375	·500	·250	·525	·30	·21
$3\frac{1}{2} \times 3\frac{1}{2}$	·300	·425	·500	·275	·575	·33	·23
4 × 4	·300	·425	·500	·300	·625	·36	·25
5 × 5	·375	—	·500	·350	·700	·42	·29
6 × 6	·450	—	·625	·425	·775	·48	·34
8 × 8	·550	—	·750	·550	·950	·60	·42
9 × 9	·550	—	·750	·550	1·000	·66	·46

UNEQUAL ANGLES.

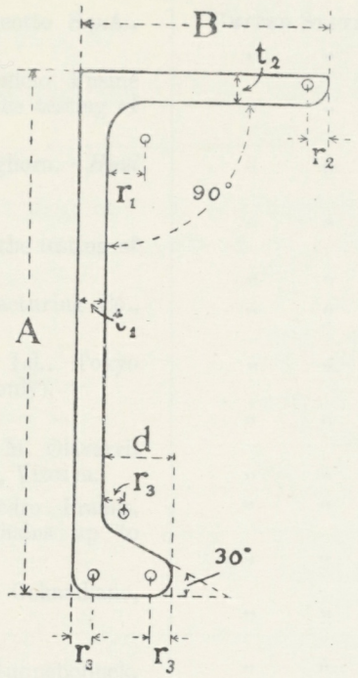


Size.	Thickness at Correct Standard Profile.			Minimum thickness rolled.	Maximum thickness rolled.	Radii	
A × B	Minimum.	Mean.	Maximum.			Root.	Toe.
	t	t	t			r_1	r_2
Inches.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.
2 × $1\frac{1}{2}$	·175	—	·300	·150	·375	·23	·16
$2\frac{1}{2} \times 1\frac{1}{2}$	·175	—	·300	·150	·400	·24	·17
$2\frac{1}{2} \times 2$	·175	—	·300	·175	·450	·26	·18
3 × 2	·250	·375	·500	·200	·500	·27	·19
3 × $2\frac{1}{2}$	·250	·375	·500	·225	·525	·29	·20
$3\frac{1}{2} \times 2\frac{1}{2}$	·250	·375	·500	·250	·525	·30	·21
$3\frac{1}{2} \times 3$	·250	·375	·500	·250	·550	·32	·22
4 × 3	·300	·425	·500	·275	·575	·33	·23
4 × $3\frac{1}{2}$	·300	·425	·500	·275	·600	·35	·24
5 × 3	·300	·425	·500	·300	·625	·36	·25
5 × $3\frac{1}{2}$	·375	—	·500	·325	·625	·38	·26
5 × 4	·375	—	·500	·325	·650	·39	·27
6 × 3	·375	—	·500	·325	·650	·39	·27
6 × $3\frac{1}{2}$	·375	—	·500	·350	·675	·41	·29
6 × 4	·375	—	·500	·350	·700	·42	·29
7 × $3\frac{1}{2}$	—	·525	—	·375	·725	·44	·31
8 × 4	—	·625	—	·425	·775	·48	·34
8 × 6	—	·625	—	·450	·800	·54	·38
9 × 4	—	·650	—	·450	·825	·51	·36
10 × 4	—	·675	—	·475	·850	·54	·38

BRITISH STANDARD SECTIONS.

LONDON.—*Revised July, 1920.*

BULB ANGLES.



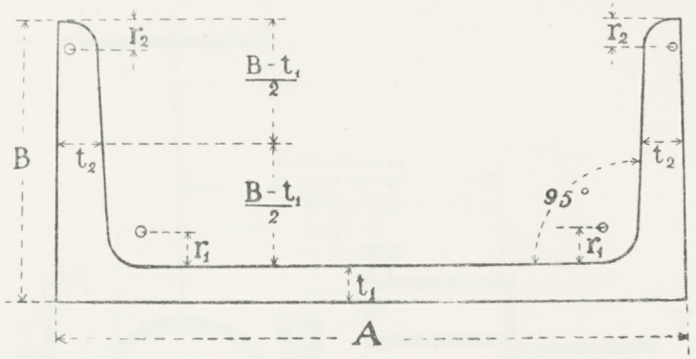
Size.	Thickness at Correct Standard Profile.		Web thickness.		Radii.			d
A × B	Web. t_1	Flange. t_2	Minimum rolled.	Maximum rolled.	r_1	r_2	r_3	
Inches.	Inch.		Inch.	Inch.	Inch.	Inch.	Inch.	Inch.
4 × 2½	·26		·21	·46	·42	·21	·16	·52
4½ × 2½	·28		·23	·48	·42	·21	·18	·58
5 × 2½	·30		·25	·50	·42	·21	·20	·65
5 × 3	·30		·25	·50	·48	·24	·20	·65
5½ × 3	·31		·26	·52	·48	·24	·22	·71
6 × 3	·33		·28	·54	·48	·24	·24	·78
6 × 3½	·33		·28	·54	·54	·27	·24	·78
7 × 3	·38		·33	·59	·48	·24	·28	·91
7 × 3½	·38		·33	·59	·54	·27	·28	·91
8 × 3	·40		·35	·61	·48	·24	·32	1·04
8 × 3½	·40		·35	·61	·54	·27	·32	1·04
9 × 3½	·43		·38	·65	·54	·27	·36	1·17
10 × 3½	·45		·40	·67	·54	·27	·40	1·30
11 × 3½	·48		·43	·70	·54	·27	·44	1·43
12 × 3½	·50		·45	·73	·54	·27	·48	1·56
12 × 4	·50		·45	·73	·60	·30	·48	1·56
13½ × 4	·54		·49	·77	·60	·30	·54	1·75
15 × 4	·57		·52	·82	·60	·30	·60	1·95

Where the thickness of Bulb Angle is greater than the Standard thickness, the flange and web will not be of the same thickness; generally for each ·05 inch increase in the thickness of the web the thickness of the flange will be increased ·025 inch.

BRITISH STANDARD SECTIONS.

LONDON.—*Revised July, 1920.*

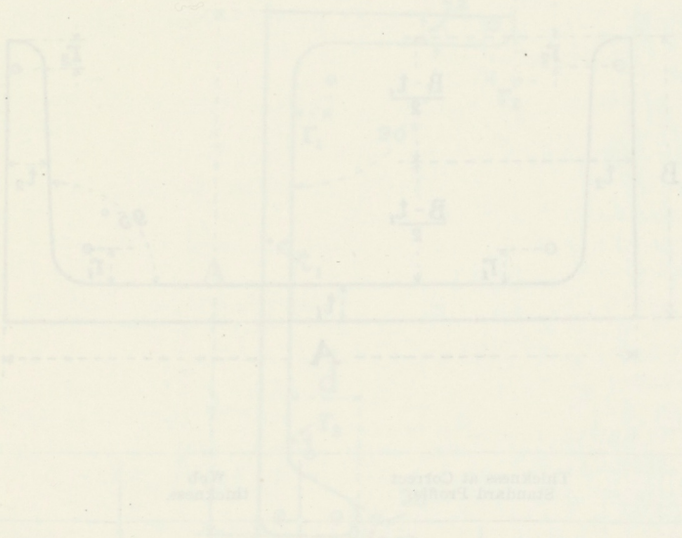
CHANNELS.



Size.	Thickness at Correct Standard Profile.		Web thickness.	Radii.	
Web and Flanges.	Web.	Flange.	Minimum rolled.	Root.	Toe.
A × B	t_1	t_2		r_1	r_2
Inches.	Inch.	Inch.	Inch.	Inch.	Inch.
3 × 1½	·20	·28	·20	·30	·15
4 × 2	·24	·31	·24	·36	·18
5 × 2½	·25	·38	·25	·42	·21
6 × 3	·25	·38	·25	·48	·24
6 × 3½	·28	·48	·28	·54	·27
7 × 3	·26	·42	·26	·48	·24
7 × 3½	·30	·50	·30	·54	·27
8 × 3	·28	·44	·28	·48	·24
8 × 3½	·32	·52	·32	·54	·27
9 × 3	·30	·44	·30	·48	·24
9 × 3½	·34	·54	·34	·54	·27
10 × 3	·32	·45	·32	·48	·24
10 × 3½	·36	·56	·36	·54	·27
12 × 3½	·35	·50	·35	·54	·27
12 × 3½	·40	·60	·40	·54	·27
12 × 4	·40	·60	·40	·60	·30
15 × 4	·41	·62	·41	·60	·30
17 × 4	·48	·68	·48	·60	·30

The Standard thickness of flanges of Channel bar is to be measured at distances half way between the extreme edges of the flanges and the inner side of the web.

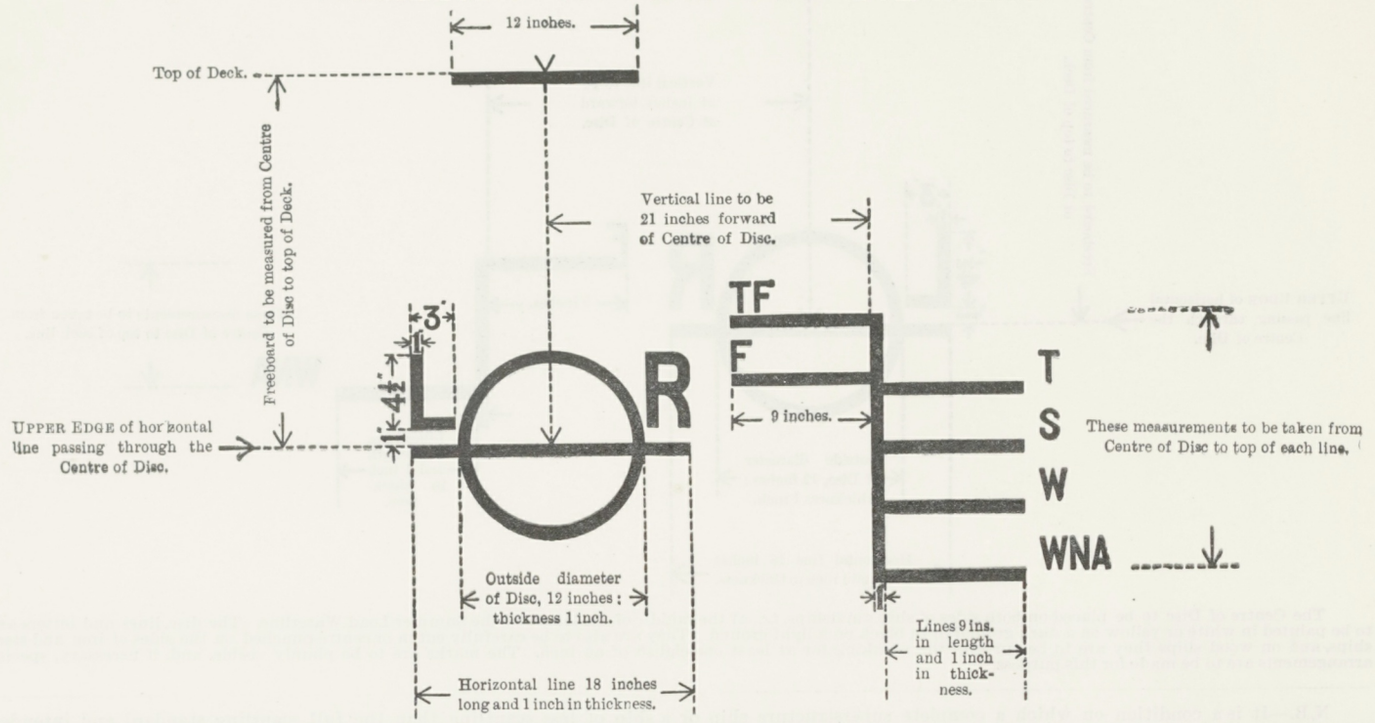
The web of Channel bars can be increased beyond the Table thickness but the thickness of flanges remains constant



ASSIGNMENT OF FREEBOARD.

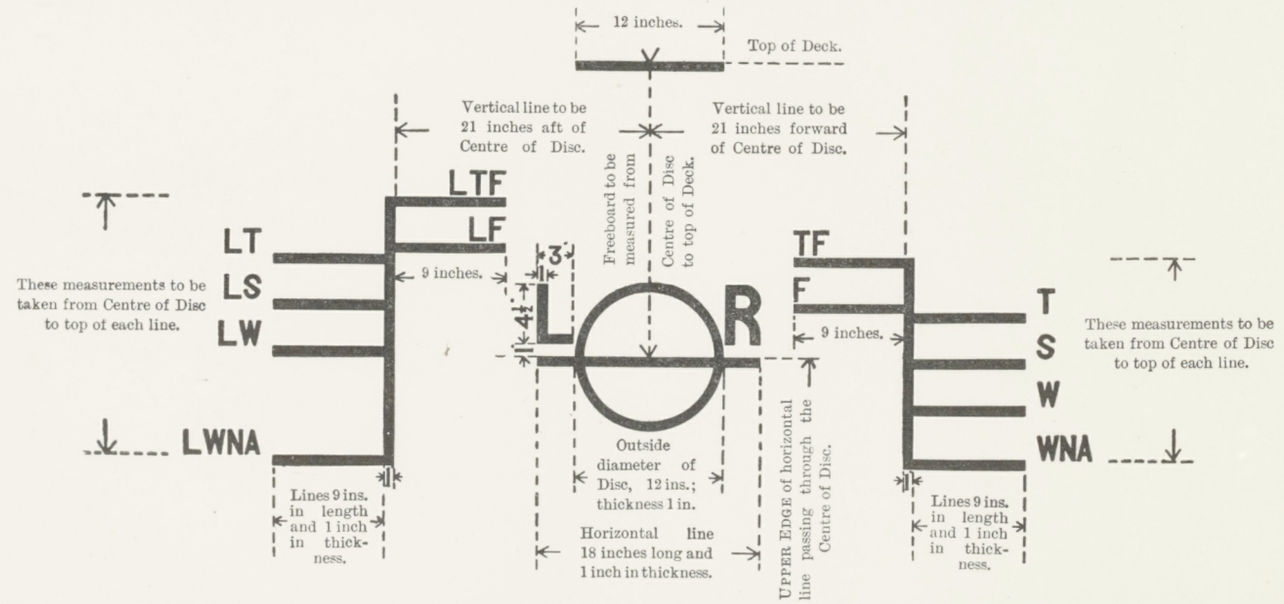
The Committee of Lloyd's Register are empowered to assign freeboards to British ships and to Ships registered in other countries. Forms of application for the assignment of freeboard can be obtained from the London, or other, offices of the Society.

FREEBOARD MARKING FOR STEAMERS.



The Centre of Disc to be placed on both sides of ship amidships, *i.e.*, at the middle of the length of the Summer Load Waterline. The disc, lines and letters are to be painted in white or yellow on a dark ground or in black on a light ground. They are also to be carefully cut in or centre-punched on the sides of iron and steel ships, and on wood ships they are to be cut into the planking for at least one-eighth of an inch. The marks are to be plainly visible, and, if necessary, special arrangements are to be made for this purpose. Ships over 330 feet in length are not required to be marked with the W.N.A. line.

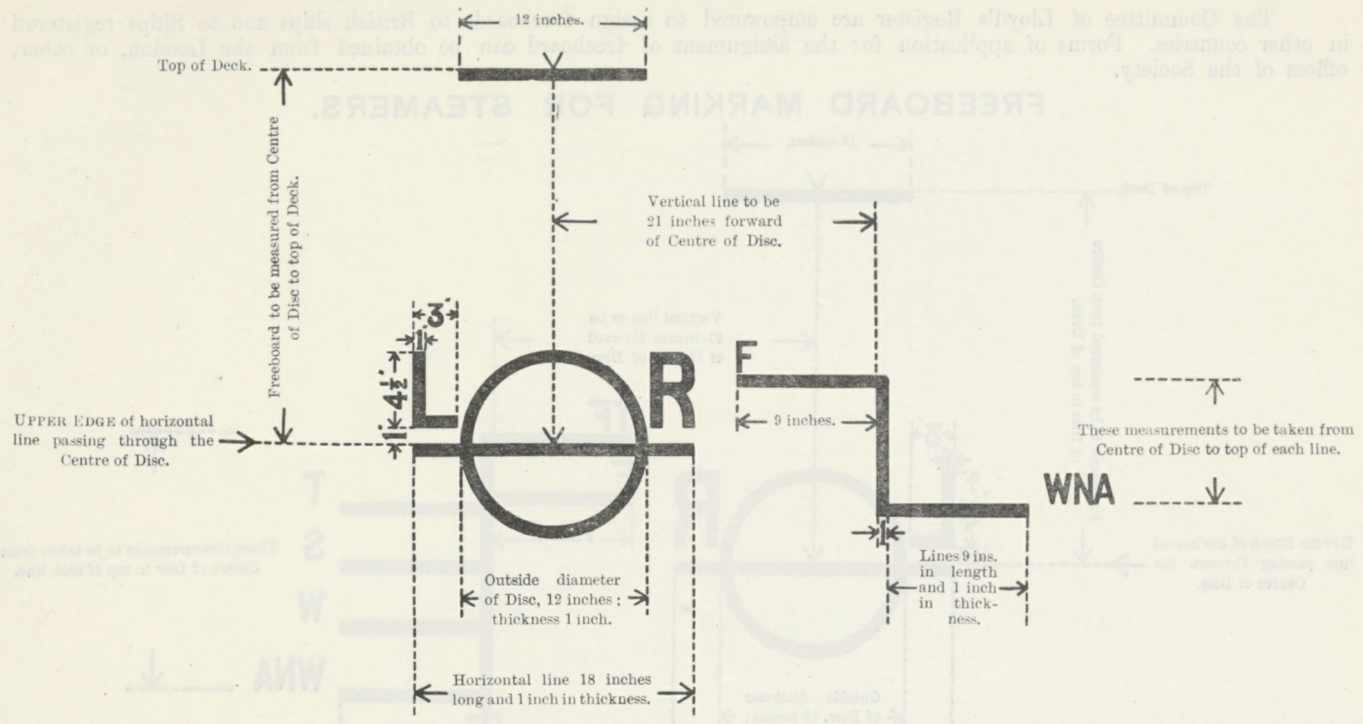
FREEBOARD MARKING FOR STEAMERS CARRYING TIMBER DECK CARGOES.



The Centre of Disc to be placed on both sides of ship amidships, *i.e.*, at the middle of the length of the Summer Load Waterline. The disc, lines and letters are to be painted in white or yellow on a dark ground or in black on a light ground. They are also to be carefully cut in or centre-punched on the sides of iron and steel ships, and on wood ships they are to be cut into the planking for at least one-eighth of an inch. The marks are to be plainly visible, and, if necessary, special arrangements are to be made for the purpose. Ships over 330 feet in length are not required to be marked with the W.N.A. line.

N.B.—It is a condition on which a complete superstructure ship or a ship of less scantling than the full scantling standard and intended for other than river or inland water service is classed in the Society's Register Book that the freeboard assigned shall be marked on the ship's sides as above prescribed. If the ship proceed to sea with a less freeboard than that approved by the Committee, or if the freeboard mark be placed higher than the position assigned by the Committee, the ship will be liable to have her class expunged from the Register Book.

FREEBOARD MARKING FOR SAILING SHIPS.



The Centre of Disc to be placed on both sides of ship amidships, *i.e.*, at the middle of the length of the Summer Load Waterline. The disc, lines and letters are to be painted in white or yellow on a dark ground or in black on a light ground. They are also to be carefully cut in or centre-punched on the sides of iron and steel ships, and on wood ships they are to be cut into the planking for at least one-eighth of an inch. The marks are to be plainly visible, and, if necessary, special arrangements are to be made for this purpose.

N.B.—It is a condition on which a complete superstructure ship or a ship of less scantling than the full scantling standard and intended for other than river or inland water service is classed in the Society's Register Book that the freeboard assigned shall be marked on the ship's sides as above prescribed. If the ship proceed to sea with a less freeboard than that approved by the Committee, or if the freeboard mark be placed higher than the position assigned by the Committee, the ship will be liable to have her class expunged from the Register Book.

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